SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

1985 Ship Production Symposium
Volume I

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NAVAL SURFACE WARFARE CENTER

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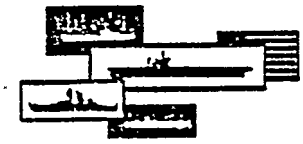
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"Moving Ahead with Implementation of Advanced Technology"

National Shipbuilding Research Program

1985 SHIP PRODUCTION SYMPOSIUM



Sponsored'by:

Society of Naval Architects and Marine Engineers
Ship Production Committee

'= SEPTEMBER 1 l - 13,1985 • =

LONG BEACH, CALIFORNIA
HYATT REGENCY HOTEL

SESSION TOPICS:

Flexible Manufacturing

- **Facilities and Environmental Effects**
- **Surface Preparation and Painting**
- **Education and Training**
- **Industrial Engineering**
- **Human Resource innovation**
- **Welding**
- **Design/Production Integration**
- **Standards and Specifications**
- **Outfitting and Production Aids**
- **Navy Ship Production**

PREFACE

The NSRP 1985 Ship Production Symposium was held in Long Beach, California on September 11-13, 1985. It was sponsored by the Society of Naval Architects and Marine Engineers and the Ship Production Committee.

The thrust of the program was "Moving Ahead With Implementation of Advanced Technology" and focused on the ongoing projects of the panels of the Ship Production Committee. Each panel was responsible for one of the symposium sessions and selected the 2-4 papers to be presented within that session. An additional session was added to cover Navy Production and Ship Repair.

The symposium was a project of the SP-9 Education Panel and was financed through SP-9 with financial contributions from each of the other panels. It is one of many projects managed and cost-shared by The University of Michigan for the National Shipbuilding Research Program. The Program is a cooperative effort of the Maritime Administration's Office of Advanced Ship Development, the U.S. Navy, the U.S. shipbuilding industry, and selected academic institutions. .

The personal efforts of many people vitally interested in and committed to the ship production industry and research made this symposium an informative, successful experience. Grateful thanks to each of you.

Wendy Barhydt
1985 Symposium Manager

TABLE OF CONTENTS

PAGE

OVERVIEW OF NSRP
J.W. Brasher 1

KEYNOTE ADDRESS:
The Honorable James F. Goodrich,
Undersecretary of the Navy 5

OVERVIEW OF SP-l/3
Richard Price, Chairman 24

GROUP TECHNOLOGY/FLOW APPLICATIONS IN PRODUCTION SHOPS
William S. Oakes, Lyn Haumschilt 36

WEB FABRICATION LINE: RESULTS OF A FEASIBILITY STUDY
Michael Tomzig 49

THE NESTING AND MARKING OF SHIP PARTS CUT FROM STEEL PLATE
Harry Hooper 54

OVERVIEW OF SP-2.
Louis Chirillo, Chairman 103

A NEW SHIPBUILDING MEASUREMENT TOOL - PHOTOGRAMMETRY FOR MEASURING CIRCULARITY OF SUBMARINE HULLS
Lawrence R. Jacobsen, Philip N. Biondo l05

APPLICATION OF ZONE LOGIC AND OUTFIT PLANNING CONCEPTS TO OVERHAUL, MODERNIZATION AND REPAIR OF U.S. NAVY SHIPS
Dennis C. Moen 137

PIPE FABRICATION TO SUPPORT MODERN SHIP CONSTRUCTION METHODOLOGY: THE INPLEMENTATION OF AN INTEGRATED FABRICATION CONTROL PHILOSOPHY IN A MODERNIZED SHIPYARD PIPE SHOP
David Saginaw II 161

ZONE OUTFITTING IN A CANADIAN GREAT LAKES SHIPYARD (THE FIRST FOUR YEARS)
Alan J. Telfer 211

THE USE OF STATISTICAL METHODS IN DIMENSIONAL PROCESS CONTROL,
Stephen Krajcsik 246

THEODORE ROOSEVELT (CVN 71) SCHEDULE COMPRESSION
Irving G. Halper 265

TABLE OF CONTENTS (Cont.)

PAGE

OVERVIEW OF SP-4
Baxter Barham, Chairman 281

ENGINEERING MANAGEMENT FOR ZONE CONSTRUCTION OF SHIPS
Thomas Lamb 300

PRODUCIBILITY AS A DESIGN FACTOR IN NAVAL SHIPS
Lcdr. Michael L. Bosworth, Capt. Clark Graham 403

OVERVIEW OF SP-5
Frank Long, Chairman 443

MULTI-SKILLED SMALL WORK TEAMS IN A ZONE CONSTRUCTION ENVIRONMENT
Dan Stravinski 444

LABOR-MANAGEMENT COOPERATION IN THE DESIGN AND OPERATION OF EMPLOYEE INVOLVEMENT
Stephen Sullivan, David Case 461

OVERVIEW OF SP-6
Tom O'Toole, Secretary 472

STANDARDIZATION FROM MARINE EQUIPMENT SUPPLIERS PERSPECTIVE
Parker L. Hay 498

MAKING THE RIGHT CONNECTION - PIPING SYSTEMS PAST, PRESENT, AND FUTURE
Dave Kelly 511

SHIPBUILDING STANDARDS OF THE U.S. AND THE WORLD
Robert B. Toth 528

OVERVIEW OF THE NSRP

Jesse Brasher
Ingalls Shipbuilding
Chairman, Ship Production Committee

Good morning and welcome to the 1985 Ship Production Symposium. This symposium, which is an annual event, is a vital part of the overall National Shipbuilding Research Program. Our theme this year is 'Moving Ahead With The Implementation of Advanced Technology".

There are many individuals responsible for-the success of this symposium - not all of them present here - and only two will be noted. Now, Howard thinks I am going to call his name but he will remain a nameless Texan and the two I will honor are Wendy Barhydt and Mary Casto.

We have an impressive program this week; and this morning we have three exceptional keynote speakers. It would be an error not to mention the symposium attendees. If you will look to your left or to your right, chances are good that you will see someone that is "somebody". Historically.the attendees at these symposia represent the overwhelming majority of shipbuilders in this country and some oversees. The individual attendees would easily fit into anyone's compilation of a "Who's Who in the American Marine Industry".

The National Shipbuilding Research Program has experienced a steady growth. Over the years, as needs have been identified and articulated, programs have been implemented to address these needs. The contribution of the SPC to the present program has a solid foundation, thanks again to the leadership of people like Ellsworth Peterson, Ed Petersen, Jack Garvey, Bob Schaffran, Pete Palermo, Jack McInnis, the Panel Chairmen and the Program Managers.

The theme of this year's symposium, "Moving Ahead With The Implementation of Advanced Technology", warrents a comment you will appreciate as the week progresses. Advanced technology in this program has a broad interpretation. It includes hardware, software, management, training, quality, as well as a host of other topics which contribute to, or control the cost of, shipbuilding. This symposium and this interpretation are consistant with industry cost drivers which must be addressed.

Being sensitive to and addressing the needs of the shipbuilding industry is what this program is all about. That is precisely why the number of Panels have been added to the Committee such that ten exist, an eleventh is in the approval cycle and a twelfth is under consideration. New panels are from time to time created to address new needs, new and perhaps specialized technology, such as flexible automation. That is not the end of the story, however. Our newest panel, Human Resources, arose from the ashes of an earlier panel that had been phased out. Other, older panels address current

technology in their respective fields. New technology is a way of life and must be addressed even in such "old" subjects as welding. There' is no area of shipbuilding that is considered beyond improving.

New things just don't happen in shipbuilding; they must be made to happen. Sometimes though, they must be made to.happen over someone's prostrate body. This program has the ingredients to make things happen even in the present shipbuilding environment. Most of you know what I am about to say, but let me briefly reiterate for you:

First - The program is successfully addressing a real need.

Second - The program is truly national, representing all geographic areas and large, medium and small industries.

Third - The three funding sources - the Maritime Administration, the U.S. Navy and the marine industry all have a financial interest in making the program work and are willing partners in the endeavor, and

Finally - We have talent, experience and leadership in abundance.

For those of you who have had an opportunity to see and read the new Journal of Ship Production, Volume 1, Number 1, there is an excellent presentation by Baxter on the many projects undertaken by the SPC and it is impossible to summarize that here. Individual reports on some completed projects will be delivered at this symposium. For fiscal year 1985, about 50 new projects have been selected for research. Still others are in the wings which will be addressed in FY 1986.

The work of the committee panels is a story unto itself and is, of course, our main story. For the benefit of the committee members and the 300 plus panel members, a quote from my recent testimony before the subcommittee on Merchant Marine, U.S. House of Representatives, appears appropriate here: "In my opinion the NSRP is by far the most effective broad based shipbuilding/ship design modernization program in this country today. We speak with pride of this cooperative program, whom the program represents, what the program has accomplished and finally what it is yet to accomplish. This year the 10 panels will conduct research and development on about 50 projects directed to reducing the cost of shipbuilding. We have a fine program, but it can be better. We have some good, perhaps even great, shipyards, but they can be better. It.is our objective to continue to make a significant contribution to the betterment of the NSRP and to the shipbuilding process."

There is another story in the NSRP that is less well-known, but is a vital part of the overall program and I will even call it the glue that holds the program together. Bear with me for a few more minutes as I list some of these activities which are either generic to the program or are policy matters, without which the program would be less effective. .

1. The intensity of the program has been such that the size of the full SPC limited the number of meetings per year and the attendance. Our leadership saw a need and formed the Executive Control Board. This smaller group meets about 4 times a year and greatly facilitates the work of the full committee and the program.

2. Symposia such as you are now attending are an instrument of the committee and, as noted earlier, a vital annual event.

3. The ink was hardly dry on the National Research Council report on "Toward More Productive Naval Shipbuilding" when the committee contacted the Navy in reference to the report recommendations. One particular recommendation concerned an industry/Navy task force on CAD/CAM. Since that initial contact, a series of actions has taken place which has included a definition of the need, an initial strawman, and finally this month, a task force recommendation.

4. The Journal of Ship Production recently initiated in SP-9 has been an instant success and meets a need of every panel and, indeed, the program.

5. Routinely, your committee is called upon to meet a need by someone, somewhere. This year we have sponsored workshops, formed several task forces and at least one high level industry/Navy interface group.

6. You and your efforts are represented at national and international symposia. These include the M-TAG, SAE and ICCAS. This past July, testimony on behalf of the committee was presented before the Biaggi Subcommittee.
While I am at this point, it is necessary to point out that these tasks are almost exclusively performed by volunteers se volunteers to chair the task force or ad hoc committee, to serve on them and to make the speeches. Now these people have full time jobs back home, but I have to tell you that the response of each of you to these requests and needs has been nothing less than outstanding. This willingness to go the extra 500 miles is characteristic of our members and is responsible for the success of the program.

A word on the future - I am excited by what is before us. The productive cost reduction needs of the country's shipyards should ensure full employment for the NSRP. Interest in the NSRP is.at a high level and, to steal a thought, our task should be to work ourselves out of a job. Our challenge is great and our opportunities bountiful. That only means our victory will 'be greater. We can do it.

One final point before closing, in case you are asking what effect the program is having. For the National Shipbuilding Research Program, a recent public document reported an estimated savings of 75 million dollars from a total funding of 6.7 million dollars.

That is not a bad return on your investment and, actually, that is not the end of the story since savings will continue to accrue as a new technology receives continued and wider use.

As I reread this Overview my thought was, "Hey, that's the type program I would like to be associated with". The reason for that is people -- people such as yourselves.

THANK YOU.

REMARKS BY
HONORABLE JAMES GOODRICH
UNDER SECRETARY OF THE NAVY
1985 SHIP PRODUCTION SYMPOSIUM
LONG BEACH, CALIFORNIA
WEDNESDAY, 11 SEPTEMBER 1985

LADIES AND GENTLEMEN, GOOD MORNING,

IT'S A PLEASURE TO BE HERE, AMONG SO MANY FRIENDS AND ASSOCIATES I HAVE KNOWN OVER THE YEARS, AND HAVING SPENT MORE THAN FOUR DECADES IN THE SHIPBUILDING INDUSTRY, I HAVE BEEN THROUGH BOTH PERIODS OF "FEAST" AND "FAMINE/' MANY OF YOU HAVE SHARED SOME OF THOSE TIMES WITH ME; IT'S GOOD TO SEE YOU AGAIN,

NOW, HAVING SPENT MORE THAN FOUR YEARS IN PUBLIC SERVICE AS UNDER SECRETARY OF THE NAVY, I'VE SEEN THE PROBLEM AND ISSUES WE'VE FACED FOR YEARS, FROM ANOTHER VIEWPOINT, HAVE RECEIVED, SHALL WE SAY FOR LACK OF A BETTER WORD, A "UNIQUE" EDUCATION IN THE SOMETIMES TRANQUIL BUT MORE OFTEN STORMY RELATIONSHIP, BETWEEN OUR NATION'S SHIPBUILDERS AND THE DEPARTMENT OF THE NAVY,

BUT IN PREPARING FOR TODAY'S TALK, I DECIDED, AT FIRST, TO CONSIDER JUST WHAT TYPE OF QUESTIONS 'WERE PROBABLY 0N YOUR MINDS, AND ADDRESS MYSELF TO THEM ON SECOND THOUGHT, HOWEVER, I RECALLED THAT SUCH AN APPROACH CAN OFTENTIMES LEAD A PUBLIC SPEAKER ASTRAY

I WAS REMINDED OF THE STORY OF THE YOUNG BOY WHO CAME IN ONE DAY FROM PLAYING WITH HIS FRIENDS HIS MOTHER WAS PREPARING DINNER WHEN HE ASKED, ''MOMMY,, WHERE DO I COME FROM'?"

NOW, MOM HAD BEEN ANTICIPATING THIS QUEST1ON, AND WORK1NG ON HER ANSWER TO IT, EVER SINCE SHE HAD BEEN IN NURSES TRAINING YEARS BEFORE, SO SHE IMMEDIATELY STOPPED WHAT SHE WAS DOING, TOOK HER SON INT0 THE LIVING ROOM, SAT HIM DOWN ON THE SOFA, AND GAVE HIM THE ANSWER THAT SHE HAD WORKED SO LONG IN PREPARING,

THE BOY SAT VERY STILL ..... AND LISTENED VERY CAREFULLY, HE WAS SURPRISED BY SOME OF II.. AND CONFUSED BY SOME OF IT,

WHEN MOM WAS FINISHED, SHE ASKED, "DOES THAT ANSWER YOUR QUESTION?" .

HER BOY REPLIED, "WELL, I GUESS SO ... BUT JOEY DOWN THE STREET SAID HE'S FROM CHICAGO ..... AND I WAS JUST WONDERING....

SO, TAKING MOM'S LESSON TO HEART, RATHER THAN TRYING TO ANTICIPATE YOUR QUESTIONS, I 'LL GIVE YOU THE DEPARTMENT OF THE NAVY'S PERSPECTIVE ON WHERE WE STAND TODAY IN SHIPBUILDING, AND WHERE WE ARE GOING TOMORROW, AFTER I'M DONE, I'LL GIVE YOU ALL A CHANGE TO ASK A FEW QUESTIONS IF YOU LIKE,

FIRST OF ALL, LET'S ESTABLISH SOME COMMON GROUND AMONG US, I THINK EVERYONE IN THIS ROOM WOULD AGREE WITH ONE INDISPUTABLE FACT:- THE UNITED STATES REMAINS, BY ITS GEOGRAPHY, HISTORY, AND ECONOMY, A MARITIME NATION WE ARE, AND WILL REMAIN FOR THE FORESEEABLE FUTURE, DEPENDENT ON OVERSEAS NATURAL RESOURCES AND COMMERCE, THIS DEPENDENCY, IN TURN, IS BASED ON UNRESTRICTED ACCESS TO THE WORLD'S GREAT WATERWAYS,

AND, I SHOULD ADD, ALL OF OUR PRINCIPAL ALLIANCES WITH OUR FRIENDS AND ALLIES WORLDWIDE ARE MARITIME ALLIANCES, THIS IS PARTICULARLY TRUE OF NATO, WHICH IS REALLY AN ALLIANCE OF EUROPE'S TRADITIONAL MARITIME NATIONS

THIS MARITIME ORIENTATION OF OUR NATIONAL DEFENSE, WHICH HAS EXISTED SINCE THE AMERICAN REVOLUTION, IS TOO OFTEN FORGOTTEN BY OUR ARMCHAIR CRITICS, WHO FANTASIZE THAT THEY ARE LITTLE NAPOLEONS"

STRUTTING AROUND THE FUTURE BATTLEFIELDS OF CENTRAL EUROPE, PLACING A TANK "HERE" AND AND I INFANTRY DIVISION "THERE," THEY DECRY MONIES SPENT ON THE SEA SERVICES, IT WOULD BE MUCH BETTER SPENT ON TANKS AND TROOPS THEY ARGUE,

THESE CRITICS, DUTIFULLY REPORTED BY THE MEDIA INCLUDING SUCH PRESTIGIOUS PUBLICATIONS AS THE WALL STREET JOURNAL WHITCH SHOULD KNOW BETTER) DENY THAT THE UNITED STATES NEEDS A STRONG NAVY, THEY PREFER INSTED A "CONTINENTAL" STRATEGY THAT RELIES 0N LEGIONS OF AMERICAN TROOPS MANNIG THE BARRICADES IN EUROPE,

WELL I HAVE SEEN THE STUDIES AND THE COMPUTER SIMULATION AND I CAN TELL YOU THAT OVER 90% OF U.S. FURNISHED EQUIPMENT AND STORES NEEDED TO SUSTAIN ANY DEFENSIVE EFFORT IN CENTRAL EUROPE WILL HAVE TO BE TRANSPORTED VIA THE GULF OF MEXICO AND ATLANTIC OCEAN SEA LANES WE LEARN THE LESSONS OF 1942 WHEN WE ALMOST LOST THAT WAR DUE TO THE EFFECTIVENESS OF THE GERMAN U-BOATS, AT OUR OWN PERIL,

A STRONG UNITED STATES NAVY TODAY CANNOT GUARANTEE US VICTORY IN A EUROPEAN STRUGGLE TOMORROW BUT, WITHOUT IT, WE ARE CONDEMNED TO ALMOST CERTAIN DEFEAT.

STILL ANOTHER STRATEGIC REALITY THAT OUR CRITICS FORGET OR IGNORE, IS THE EXISTENCE OF THE SOVIET NAVY, WHATEVER THE ORIGINAL RATIONALE FOR ITS POSTWAR EXPANSION, AND I LEAVE THAT UP TO THE ACADEMICS WHO DELIGHT IN SUCH PURSUITS, THE FACT IS THAT TODAY'S SOVIET NAVY IS AN OFFENSIVELY-ORIENTED, BLUE WATER FORCE, HELPING TO EXTEND SOVIET INFLUENCE WORLDWIDE,

AT THE VERY LEAST, MOSCOW'S FLEET CAN CHALLENGE WESTERN CONTROL OF VITAL SEA LANES IN TIME OF CRISIS OR WAR, THUS) WE HAVE IN EXISTENCE TODAY, FOR THE FIRST TIME IN FOUR DECADES, A POTENTIAL ADVERSARY WHO MAY THREATEN BY FORCE, OUR USE OF THE SEAS FOR BOTH COMMERCE AND DEFENSE-‘

THE CHALLENGE TO OUR TWO-CENTURY OLD TRADITION OF FREEDOM OF THE SEAS IS CLEAR; THE TASKS AT HAND ARE READILY APPARENT TO ALL WHO CHOOSE TO SEE,

BUT THESE TASKS REQUIRE SUFFICIENT NAVAL FORCES, FORCES WHITCCH WE ONCE HAD BUT ALLOHED TO DETERIORATE IN THE 1970'S FOR, WHEN THE REAGAN ADMINISTRATION TOOK OFFICE IN 1981, IT FACED THE PAINFUL REALITY OF A PERCIPITOUS DECLINE IN AMERICA'S NAVAL STRENGTH, A DECLINE ALMOST A DECADE OLD,

THIS WEAKENED MARITIME ARM OF OUR NATIONAL DEFENSE POSTURE WAS DUE TO MORE THAN JUST A LACK OF SHIPS, TRUE, A NAVY THAT NUMBERED MORE THAN 1000 IN 1970 HAD DECLINED TO 479 BATTLE FORCE SHIPS WHEN THE PRESIDENT TOOK OFFICE, BUT WE ALSO HAD A SITUATION WHERE WE COULD NOT COMPLETELY LOAD OUT EVEN THIS SMALLER FORCE ONCE WITH THE PROPER QUANTITIES AND TYPES OF MUNITIONS REQUIRED TO FIGHT, AND WIN, A WAR AT SEA,

SO, WE FACED THE CHALLENGE OF REBUILDING THE FLEET, WHILE AT THE SAME TIME INCREASING PERSONNEL BENEFITS TO REVERSE THE EXODUS OF OUR BEST PEOPLE, AND GETTING THE PRODUCTION LINES ROLLING AGAIN TO RESTOCK OUR DEPLETED ARMAMENTS,

FOUR YEARS LATER, OUR RESTORATION PROGRAM HAS LARGELY BEEN SUCCESSFUL, RETENTION AND RECRUITMENT FIGURES ARE UP, AND THE AMMO BINS ARE BEING REPLENISHED AT AN INCREASING RATE, WE NOW HAVE 539 BATTLE FORCE SHIPS, AN INCREASE OF 60 SHIPS SINCE FEBRUARY 1981 WE HAVE MADE A.MAJOR FINANCIAL COMMIMENT TO OUR NATION'S DOMESTIC SHIPBUILDING INDUSTRY, IN FOUR BUDGETS SINCE THE AMENDED CARTER ADMINISTRATION

BUDGET OF FY82, WE HAVE EXPENDED MORE THAN $48 BILLION ON SHIPBUILDING, OUR FY86 SHIPBUILDING REQUEST WAS FOR MORE THAN $11 BILLION IN ADDITIONAL FUNDING,

LET'S TRANSLATE THOSE FIGURES INTO HULLS, IN THE FY82 THROUGH 85 BUDGETS) WE HAVE HAD 89 SCN FUNDED SHIPS AUTHORIZED, THIS REPRESENTS A 35 PERCENT INCREASE OVER THE FOUR YEARS OF THE CARTER ADMINISTRATION,

AS OF AUGUST 1-ST OF THIS YEAR) WE HAD 95 SHIPS UNDER CONSTRUCTION OR CONVERSION IN 20 PRIVATE SHIPYARDS, WHEN YOU ADD THE FACILITIES INVOLVED IN REPAIR) OVERHAUL, CONVERSION AND MODERNIZATION WORK YOU FIND THAT IN 1985 TO DATE, 41 PRIVATE SHIPYAPDS HAVE BEEN INVOLVED IN WORK FOR THE DEPARTMENT OF THE NAVY,

NAVSEA ESTIMATES THAT THESE PRIVATE SHIPYARDS HAVE EMPLOYED 103,000 WORKERS ON NAVY JOBS, PUTTING THESE NUMBERS IN PERSPECTIVE, THESE SHIPYARDS HAVE A TOTAL EMPLOYMENT OF 112, 700, SO NAVY CONTRACTS ARE PROVIDING JOBS FOR 92 PERCENT THIS THIS TOTAL PRIVATE SHIPYARD WORK FORCE,

BY VIRTUALLY ANY MEASURE, THE DEPARTMENT OF THE NAVY'S CONTRIBUTION TO THE US, SHIPBUILDING INDUSTRY OVER THE PAST 41/2 YEARS HAS BEEN SIGNIFICANT, I WON'T PRETEND THAT WE HAVE SOLVED ALL OF INDUSTRY'S WOES -- THAT IS HARDLY THE CASE, STILL, I HAVE GROWN TIRED OVER THE PAST YEAR IN READING INDUSTRY'S OFT-EXPRESSED COMPLAINT THAT "THE NAVY IS NOT DOING ENOUGH," I THINK THESE FIGURES BELIE THOSE CHARGES,

OF COURSE; WITH A DEFENSE BUDGET NEAR AUTHORIZATION THAT ONLY COMPENSATES FOR INFLATION, THERE WILL BE FURTHER FISCAL PRESSURES, QUITE FRANKLY, WE ARE STRUGGLING AT THIS TIME TO SUSTAIN THE FORWARD MOMENTUM WE HAVE MAINTAINED SINCE 1981, ON CAPITOL HILL, MUCH OF THE INITIAL BI-PARTISAN ENTHUSIASM FOR THE REBUILDING OF THE NATION'S ARMED FORCES HAS WANED, MUCH OF THE SERIOUS CONSIDERATION OF OUR NATION'S' DEFENCE NEEDS HAS GIVEN WAY TO POLITICAL GRANDSTANDING AND POSTURING WITH TOILET SEATS AND CLAW HAMMERS,

SO, AS THE BUDGET BATTLES INCREASE IN DIFFICULTY, THE DEPARTMENT WILL REDOUBLE ITS EFFORTS TO GET MAXIMUM UTILITY FROM EACH TAXPAYER DOLLAR EXPENDED

UNFORTUNATELY, FOR THE SHIPBUILDING INDUSTRY, THIS WILL PROBABLY MEAN A DARWINIAN "SURVIVAL OF THE FITTEST" ENVIRONMENT, IN TODAY'S BUDGETARY CLIMATE, THE UNITED STATES NAVY CANNOT AFFORD To SUBSIDIZE NON-COMPETITIVE INDUSTRIES, BE THEY ORDNANCE MANUFACTURERS OR SHIPYARDS, AS SECRETARY OF DEFENSE WEINBERGER STATED IN HIS MOST RECENT REPORT TO CONGRESS "THE DEFENSE BUDGET IS NEITHER THE PRIMARY TOOL OF ECONOMIC STABILIZATION POLICY, NOR A JOB PROGRAM, IT SHOULD NOT BE USED SOLELY TO STIMULATE INDUSTRIAL DEVELOPMENT

I AM CERTAIN THAT MANY OF YOU IN THIS AUDIENCE SHARE WITH ME A CONCERN OVER PRESERVING NEW CONSTRUCTION FACILITIES HERE ON THE WEST COAST, I WOULD AGREE W1TH YOU THAT IT'S IMPORTANT .... BUT ONLY IF YOU CUT YOUR LABOR COSTS, MODERNIZE YOUR PLANT,. AND IMPROVE YOUR PRODUCTIVITY, YOU'LL GET THE BUSINESS IF NOT IT WILL GO TO YOUR COMPETITORS WHO CAN OFFER A BETTER PRICE,

AS EVIDENCE OF OUR COMMITMENT TO COMPETITION, WE ARE TAKING A HARD LOOK AT THE ISSUE OF PRIVATE VERSUS PUBLIC SECTOR SHIPYARD OVERHAULS, AS SOME OF YOU KNOW THE FY85

CONTINUING RESOLUTION AUTHORITY ESTABLISHED A TEST PROGRAM TO ACQUIRE THE OVERHAUL OF TWO OR MORE VESSELS BY COMPETITION BETWEEN PRIVATE AND PUBLIC SHIPYARDS THE SUCCESSFUL BIDS HAD TO INCLUDE COMPARABLE ESTIMATES OF ALL DIRECT AND INDIRECT COSTS FOR BOTH SECTOR SHIPYARDS,

WE DECIDED TO COMPETE THE REGULAR OVERHAUL-OF THE USS DULUTH, AN AMPHIBIOUS TRANSPORT DOCK SHIP, PROPOSALS FROM TEN OFFERORS, EIGHT FROM THE PRIVATE SECTOR AND TWO NAVAL SHIPYARDS, WERE RECEIVED, NORTHWEST MARINE IRON WORKS OF PORTLAND, OREGON, SUBMITTED THE LOW OVERALL BID AND HAS BEEN AWARDED THE CONTRACT TO OVERHAUL DULUTH,

I WOULD LIKE TO ADD THAT NORTHWEST MARINE'S BID WAS SIGNIFICANTLY LOWER THAN THE LOWEST PUBLIC SECTOR SHIPYARD, NORTHWEST TACKLED THE ISSUE OF HIGHER COSTS FOR NEST COAST YARDS BY OBTAINING LABOR'S CONSENT TO A 25% WAGE REDUCTION, IT'S JUST SUCH EXAMPLES OF TEAMWORK BETWEEN MANAGEMENT AND LABOR THAT ARE GOING TO REAP SUBSTANTIVE REWARDS, IN THE WAY OF NAVY CONTRACTS IN THE FUTURE,

TO COMPLEMENT SUCH EFFORTS ON THE PART OF PRIVATE SHIPYARDS, WE ARE DOING OUR PART BY ANALYZING CLOSELY JUST WHO IS GOING TO DO THE BEST WORK FOR US AT LEAST COST,

SO, LONG BEACH NAVAL SHIPYARD, WHICH WAS THE LOW PUBLIC SECTOR BIDDER, WILL BE GIVEN THE SECOND SHIP ASSIGNED IN THE TEST, THE USS CLEVELAND, CLEVELAND IS THE SAME CLASS AS DULUTH, SO THE WORK I WOLVED SHOULD BE SIMILAR

THE RECORDED COST DATA FROM THESE TWO OVERHAULS WILL PROVIDE THE BASIS FOR FUTURE ANALYSIS AND REPORTS THAT WILL LARGELY DETERMINE WHO GETS WHAT IN THE WAY OF THE NAVY'S OVERHAUL WORK,

THE BUTTOM LINE IS THAT IN THE FUTURE YOU MAY BE ABLE TO BID FOR WORK THAT YOU NEVER MOULD HAVE GOTTEN 1N THE PAST, BUT THERE WILL BE NO GIVEAWAYS, IF YOU WANT IT, YGU'RE GOING TO HAVE TO BEAT YOUR COMPETITORS,

THE PUBLIC VERSUS PRIVATE SHIPYARD COMPETITION IS JUST ONE SMALL FACET OF THE "NEW" WAY WE'RE DOING BUSINESS IN THE DEPARTMENT OF THE NAVY‘ THE FUNDAMENTAL SEA CHANGE IN

/MORE.

PROCUREMENT WE HAVE INSTITUTED OVER THE PAST FOUR YEARS HAS BEEN DUE TO THE VIGOROUS MANAGEMENT REFORMS INITIATED BY THE SECRETARY OF DEFENSE, HE HAS REVERSED THE TREND, WHICH DATED BACK TO THE EARLY 1960'S, OF CENTRALIZING MANAGEMENT FUNCTIONS AND ERECTING LARGE, BUREAUCRATIC STRUCTURES TO EXECUTE ITS DECISIONS, HE HAS RETURNED TO THE SECRETARY OF THE NAVY THE AUTHORITY TO MANAGE HIS OWN DEPARTMENT, AT THE SAME TIME, HE HAS HELD THE SECRETARY ACCOUNTABLE FOR ACHIEVING REAL REFORM IN THE NAVY'S DEVELOPMENT AND PROCUREMENT PROCESS, .

THE MAJOR ACCOMPLISHMENTS THE DEPARTMENT HAS ACHIEVED OVER THE LAST FOUR YEARS FALL INTO FIVE BROAD CATEGORIES, SINCE YOUR SYMPOSIUM IS LOOKING TO THE FUTURE, I THINK IT APPROPRIATE TO CLOSE WITH A BRIEF DISCUSSION OF THESE CATEGORIES, THEY DEFINE THE NEW" "WAY WE ARE DOING BUSINESS, AND WILL BE, FOR THE FORESEEABLE FUTURE,

FIRST, AS I PREVIOUSLY INDICATED, WE HAVE PUT TRUE COMPETITION BACK INTO OUR PROCUREMENT PROCESS. THE SOVIET "GOSPLAN" TYPE OF PROCUREMENT PHILOSOPHY IS GONE, IN FY81 WE COMPETED ONLY 25% OF OUR PROCUREMENT DOLLARS, THROUGH

MAY THIS YEAR, THAT PERCENTAGE HAD GROWN TO 42,3%, WITH A FY85 GOAL OF 45% OF PARTICULAR INTEREST TO YOU, IN FY30 LESS THAN 16% OF OUR SHIPBUILDING PROGRAM WAS COMPETED, IN 1985, THAT FIGURE HAS' INCREASED ALMOST FIVE TIMES, TO MORE THAN 84%.

I CANNOT EMPHASIZE ENOUGH THE FACT THAT COMPETITION WORKS, BY COMPETING THE PREVIOUSLY SOLE-SOURCED AEGIS CRUISER PROGRAM, WE SAVED MORE THAN $380 MILLION, IN NOVEMBER OF LAST YEAR; WHEN WE COMPETED SIX CONTRACTS FOR THE CONSTRUCTION OF TEN SHIPS, THE SAVINGS TOTALLED $243 MILLION, IN FACT, THE TOTAL FY83 AND FY84 SAVINGS ON SHIP PROCUREMENT, MORE THAN $23 BILLION, HAS ALLOMED US TO FUND THE ENTIRE BATTLESHIP MISSOURI AND, ADDITIONALLY, GIVE THE AIR FORCE $640 MILLION TO ASSIST IN THE MX MISSILE PROGRAM,

TO COMPLEMENT OUR RENEWED EMPHASIS ON COMPETITIOIN, WE HAVE INSTITUTED MANAGEMENT INITIATIVES TO STOP "GOLD-PLATING" AND GET CONTROL OVER DESIGN CHANGES, WE HAVE DISCIPLINED OUR BAD HABIT OF INCREASING AND CHANGING REQUIREMENTS FOR COMBAT SYSTEMS AND HOST PLATFORMS DURING CONTRACT EXECUTION,

THESE HABITS, IN THE PAST, HAVE LED TO PROCUREMENT DISASTERS, LITIGATION IN THE COURTS, AND MOUNTAINS OF CLAIMS AGAINST THE GOVERMENT.

WE HAVE ESTABLISHED BOTH AIR CHARACTERISTICS AND SHIP CHARACTERISTICS IMPROVEMENT EOARDS, THESE BOARDS ACT TO CONTROL DESIGN AND EQUIPMENT CHANGES IN PRODUCTION OF AIRCRAFT AND SHIPS, NECESSARY CHANGES AND DESIGN MODERNIZATION ARE MADE ONLY WITH NEW ANNUAL CONTRACTS AND ARE NOT INSTITUTED PIECEMEAL IN THE MIDDLE OF PRODUCTION RUNS,. NO CONTROL OR ENGINEERING CHANGES CAN BE SUBMITTED FOR NEGOTIATION WITHOUT THE SINGNATURE OF THE COMMANDANT OF THE MARINE CORPS OR THE CHIEF OF NAVAL OPERATIONS AND THE SECRETARY'S, -

ANOTHER CHANGE IN THE WAY WE'RE DOING BUSINESS IS IN R&D FUNDING, WE'VE INCREASED THE PRODUCTIVITY OF OUR R&D DOLLARS AND STOPPED "CHASING R&D RAINBOWS/' BECAUSE WE HAD TOO FEW DOLLARS SPREAD OVER TOO MANY PROGRAMS, THE 551 PROGRAMS WE INHERITED 'IN 1981 HAVE BEEN REDUCED TO 400 TODAY, WE HAVE CANCELLED A NUMBER OF MASSIVE DEVELOPMENT PROGRAMS WHERE THE PAYOFF IN CAPABILITY AND EFFICIENCY HAS BEEN MARGINAL, REDIRECTING THE FUNDS SAVED TO OUR MOST

ME HAVE ALSO TAKEN DECIDED STEPS TO ENSURE CONTRACT DISCIPLINE, ACCOUNTABILITY AND QUALITY ASSURANCE IN OUR DEALMGS WITH INDUSTRY, COST-PLUS CONTRACTS, ONCE CONSIDERED THE NORM ARE- NOW ACCEPTABLE ONLY AS A LAST RESORT ON HIGH RISK PROGRAMS CONTRACTS FROM THE 1970'S ON SUCH SYSTEMS AS TOMAHAWK TRIDENT, AND THE SSN 688'S HAVE BEEN RENEGOTIATED TO ElIMINATE OVERLY LENTENT TERMS FOR CONTRACTORS, ALL AIRCRAFT PROCUREMENT IS NOW DONE ON FIXED PRICE CONTRACTS, ALL SHIP PROCUREMENT IS NOW DONE Old FIXED PRICE CONTRACTS, WITH A 50/50 SHARE LINE ABOVE AND BELOW THE CONTRACT PRICE,

HOW HAS INDUSTRY RESPONDED TO THIS NEW EMPHASIS ON DISCIPLINE? AGAIN, LET'S TAKE THE SHIPBUILDING INDUSTRY AS AN EXAMPLE, BETWEEN 1982 AND AUGUST IST OF THIS YEAR WE-HAVE TAKEN DELIVERY ON 83 SHIPS, OF THESE, 32 HAVE BEEN DELIVERED EARLY AND 37 OK TINE, IN OUR SUBMARINE PROGRMS, AFTER YEARS OF LATE DELIVERIES, COST OVERRUNS, LITIGATION AND CLAIMS, ALL OF OUR SUBMARINES ARE NOW ON, OR AHEAD OF, SCHEDULE, THE NUCLEAR AIRCRAFT CARRIER THEODORE ROOSEVELT, LAUNCHED LAST OCTOBER, WAS 18 MONTHS AHEAD OF SCHEDULE AND

$100 MILLION UNDER BUDGET ONCE AGAIN, THE CRITICS WHO INSISTED THAT INDUSTRY WAS INCAPABLE OF RESPONDING TO THE NEW EFFICIENCIES AND DISCIPLINE IMPOSED BY THE NAVY HAVE BEEN PROVEN WRONG

FINALLY, AND PERHAPS MOST IMPORTANTLY, WE ARE CHANGING THE WAY WE SELECT, EDUCATE, AND REWARD THE PEOPLE WHO MANAGE OUR ACQUISITION PROGRAMS, FOR TOO LONG IT HAS BEEN A GIVEN IN THE DEFENSE THAT THAT A CONTRACTOR WITH EXPERIENCE MEETS AN OFFICER WITE MONEY, THE CONTRACTOR WITH EXPERIENCE WILL GET THE MONEY .... AND THE OFFICER WITH MONEY WILL GET SOME "EXPERIENCE' WE INTEND TO BREAK THAT CYCLE, AND PUT THE "EXPERIENCE" BACK ON OUR SIDE OF THE TABLE,

IN DECEMBER OF 1984 THE CNO AND THE SECRETARY ANNOUNCED THE CREATION OF THE MATERIAL PROFESSIONAL, OR "MP" CAREER PATTERN, THE "MP" PROGRAM IS DESIGNED TO PREPARE OUTSTANDING NAYAL OFFICERS FOR CAREERS WHICH' CONCENTRATE 0N SYSTEMS ACQUISITION, MAINTENANCE, AND READINESS FUNCTIONS, 'THE "MP" WILL FOLLOW A CAREER PATH THAT INTEGRATES OPERATIONAL TOURS WITH BUSINESS EDUCATION AND ACQUISITION MANAGEMENT EXPERIENCE

TOURS, ALMOST FORTY PERCENT OF THE NAVY'S FLAG OFFICER BILLETS HAVE BEEN SET ASIDE FOR MATERIAL PROFESSIONALS TO PROVIDE THE CAREER INCENTIVES NECESSARY TO ATTRACT HIGH QUALITY PEOPLE TO THE PROGRAM, THE CREATION OF THE MATERIAL PROFESSIONAL CAREER PATTERN REPRESENTS PERHAPS THE MOST DRAMATIC AND FAR REACHING INSTITUTIONAL CHANGE IN THE NAVY IN DECADES, IT IS A MAJOR STEP TO GET US BACK ON PAR WITH OUR COUNTERPARTS INDUSTRY

AS FAR AS FUTURE INITIATIVES, WE ARE EMBARKING ON A MAJOR PROGRAM TO REDUCE THE BUREAUCRATIC LAYERING,. BOTH MILITARY AND CIVILIAN, THAT HAS ACCUMULATED AROUND OUR ASHORE AND FLEET COMMANDS TOO OFTENTIMES THESE LAYERS HAVE STRANGLED THE INITIATIVE AND INNOVATION THAT ARE THE HALLMARKS OF OUR BEST PROFESSIONALS, THE ELIMINATION OF THE NAVAL MATERIAL COMMAND IS THE FIRST STEP TOWARDS OUR GOAL OF REDUCING ORGANIZATION BLOAT AND FREEING OUR PEOPLE OF THE. BUREAUCRATIC CHAINS THAT HAVE ENCUMBERED THEM SINCE THE 1960'S WE INTEND TO CUT THE FAT OUT OF OUR MANAGERIAL PROCESSES AND ELIMINATE NEEDLESS LAYERS OF CONTROL, SUPERVISION

AND "OVERSIGHT," ALL TOO OFTEN THEY ARE SIMPLY ENGAGED IN MAKE-WORK PROJECTS, MEMORANDUM DRAFTING, AND SAYING "NO" AND LITTLE ELSE, BOTH THE UNIFORMED AND CIVILIAN BUREAUCRACIES HAVE GOT TO START PROVIDING MORE OF THE SOLUTIONS, RATHER THAN REMAINING A SUBSTANTIAL PART OF THE PROBLEM,

IN SUMMARY I HAVE OUTLINED FOR YOU THE DEGREE OF COMMITMENT THE DEPARTMENT OF THE NAVY HAS MADE TO OUR DOMESTIC SHIPBUILDING INDUSTRY OVER THE PAST FOUR YEARS I HAVE ALSO SKETCHED FOR YOU THE FUNDAMENTAL PHILOSOPHIES THAT WE WILL BE FOLLOWING IN THE FUTURE AS WE WORK TO SUSTAIN OUR MOMENTUM IN TIMES OF BUDGETARY CONSTRAINT

THE STRUGGLE TO REBUILD THE FLEET TO 600 SHIPS BY THE END OF THE DECADE HAS LARGELY BEEN WON, WE HAVE REVERSED THE DANGEROUS DECLINE IN THIS NATION'S MARITIME STRENGTH, ARE ING
WE HAVE RESTORES AMERICA'S GLOBAL NAVAL POWER TO ENSURE THE FREEDOM OF THE SEAS SO VITAL TO OUR ECONOMY,

THE NEXT FOUR YEARS WILL SEE INCREASING EMPHASIS ON MANAGERIAL AND PROCUREMENT EFFICIENCIES, IF YOU SO CHOOSE, YOU CAN REMAIN, OR BECOME, PART OF THE TEAM,

WILL THE GOING BE TOUGH AT TIMES? OF COURSE

WILL MANY OF THE CHANGES AND NEW POLICIES MEET WITH STRENUOUS OBJECTIONS FROM VESTED INTERESTS AND ENTRENCHED BUREAUCRACIES? PROBABLY!

BUT, WE INTEND TO STAY THE COURSE, AND, AS SOMEONE ONCE OBSERVED ABOUT THE LEGEND THAT SAINT DENIS WALKED 10 KILOMETERS CARRYING HIS HEAD IN HIS HAND, "THE DISTANCE DOESN'T REALLY MATTER, IT'S ONLY THE FIRST STEP THAT IS DIFFICULT

THANK YOU, AND NOW I'LL TAKE SOME QUESTIONS,

PANEL SP-l/3

FACILITIES & ENVIRONMENTAL EFFECTS

Richard A. Price
Avondale.Shipyards

Chairman

FACILITIES/ENVIROMENTAL EFFECTS (Panel SP-l/3)

PANEL CHARTER

The primary objective of this program is to reduce cost, improve productivity and reduce the time required for new ship construction, conversion and repair In the shipbuilding industry through the implementation of new technology,

The panel members must be involved with daily operation at their shipyard and be considered a integral part of their shipyard operations. The panel must be versatile and equipped to handle a variety of tasks which will inprove productivity and producability both in the short term and long range through operation analysis.

Operations analysis may be defined as "A Systematic Procedure", employed to study all of the factors which affect the method of performing an'' operation in order to achieve maximum over-all economy. Through this study the best available method of performing each necessary part of an operation is found, and new manufacturing and maintenance developments are implemented as they become available; or are developed through research, in the continuing effort *to* move every job one step closer to continuous automatic accomplishment.

No single operation can be considered as a part of the more or less complicated process of manufacture being used. The effect of any change may be considered in the light of the entire present process of manufacture,

Only in this way, can we be sure that the suggested improvement will really produce positive results.

The program addresses all pbases of ship construction, including fabrication, assembly erection, outfitting and required shipyard services. The program also includes Environmental Effect (panel SP-3) considerations involved in facility expansions, and modifications, operations and ship production from a regulatory point of view.

PANEL SP-1 SHIPYARD FACILITIES AND ENVIRONMENTAL EFFECTS

The objective of this program is to assist U.S. shipyards in reducing cost and construction time through the development and implementation of efficient equipment and facilities and. improved work flow arrangements. The program addresses all phases of ship construction, including fabrication, assemble erection, outfitting and required shipyard services. The program also includes Environmental Effects (Panel SP-3) considerations involved in facility expansions, and modifications, operations and ship production from a regulatory point of View.

FACILITIES

I. BACKGROUND

The ship Production Committee of the Society of Naval Architects and marine Engineers re-activated Panel SP-1 Facilities July 20, 1978.

Avondale Shipyards, Inc. accepted the chairmanship and agreed to be the primary sponsor. Presently we-have 25 active members from 17 shipyards plus MarAd and Navy representation.

During the July 1978 meeting of Panel SP-1 (Facilities), it was suggested that the panel develop a consensus specification for long *range* facility plans. The purpose of the consensus specificaiton is to provide a standard format and criteria for the development of facility plans. This would be a tool for use by MarAd and a specific shipyard in conjunction with the proposed facility modernization planning program.

A five-day working conference *was* held in Atlanta, Gerorgia. Twenty-two (22) representatives from twelve (12) major shipyards attended the five-day conference and currently have a common approach for the development of long range plans.

The second step of this effort was to prepare a proposal, on a voluntary basis, for one or more shipyards to develop a long range plan for their respective y rd. The detailed proposals were submitted directly to MarAd.

Panel SP-1 (Facilities) currently has a three phase objective emphasizing improved productivity.

Phase I - Enhance the Shipbuilding Industries Long Range Facilities Plan Efforts

Phase II - Determine a Feasible method of Instituting a Cooperative High Risk Facilities Program.

Phase III - Determine a Feasible Method of Instituting a Cooperative Facilities Modernization Program

Our efforts are directed toward achieving this three-phase objective, placing emphasis on cost effective producibility.

ENVIRONMENTAL

I. OVERVIEW

During 1978, we recommended that Panel Sp-1 and SP-3 (Shipyard Environmental Effects) be combined onto one panel. the logic being that the functional responsibility generally falls under the facilities development. We thought the combined panel would consolidate our industry's efforts regarding industry consensus input during the comment period of proposed federal regulations.

We coordinate our efforts with Shipbuilders Council of America Environmental Committee when dealing with governmental agencies such *as* the Environmental Protection Agency, the Department of Labor (OSHA), the U.S. Coast Guard, and the Department of the Navy. The shipyards, on an inndivisual basis, have to address their respective state and local regulatory agencies to meet the intent of their regulations.

II. OBJECTIVE AND BACKGROUND

During the proposal period, part of our committment is to ensure that the regulations are feasible regarding compliance as well *as cost* effectiveness. We have submitted comments *to* regulatory bodies as well as conducted independent studies to establish guidelines for use in the development of *cost* effective regularions.

We have focused on such issures as: (1) Draft Development Document for the Shipbuilding and Repair Industry Drydock Points Source Category; (2) methods of receiving sewage from vessels using drydock facilities; (3) programs for complying with national Pollutant Discharge Elimination Standard Permit requirements; (4) penalties for violation of Federal Water' Pollution Control Act (FWPCA); (5) certificates for financial responsibility; and (6) the OSHA Blasting Standard Development Document.

During the recent past the shipbuilding and repair industry through Panel SP-1 (SNAKE) and the Environmental Committee of SCA have focused oiur azttention on hydrocarbon emissions. Several approaches have been considered; changing the solvent, inhibiting the photochemical rectivity (Rule 66 Calif.) developing high solid coatings, developing water base coatings, utilizing carbon absorption and/or incereation. Carbon absorption or inceneration can provide 90% emission control, however, the cost impact is prohibitive. In most cases, this type of emission control could cost as much as the paint building. During the past 3 to 5 years most mi1 spec and commercial paints comply with Rule 66. It must be noted that the shipbuilding and repair industry uses the paint specified by the owners in most *cases.* Panel 023-l of SNAME Ship Production Committee has accomplished substantial gains in the use of high solid low solvent coating.

The industry effort is over and above Rule 66 compliance. Research and Development of effective water base coatings for ships is being conducted. Under the Reagan Administration the folume of proposed regulation has definitely declined. Most shipyards are occupied with compliance *to* existing reuglation *in* such *areas* as the consolidated NPDES Permits, RCRA; hazardous Waste, hazardous Material; Individual approaches. Regarding filing as *a* transporter, generator, treater, disposer and *storage* of Hazardous Waste. SP-1 continue to keep abreast of regulatory changes which may adversely influence the shipbuilding and repair industry.

PANEL SP-1
SHIPYARD FACILITIES AND ENVIRONMENTAL EFFECTS

ROSTER

Avondale Shipyards, Inc.
Chairman, SP-l/3

National Steel & Shipbuilding Co.

Bethlehem Steel Corporation

Ingalls Shipbuilding

Bath Iron Works

General Dynamics Corporation

Peterson Builders, Inc.

St. Louis Ship

Todd Pacific Shipyard - LA Div.

Maritime Administration

Newport News Shipbuilding & Drydock

McDermott'Shipyards

Lockheed Shipbuilding

Naval Material Command

PROJECTS COMPLETED

1. Material Handling Equipment Study - Volume I and II - 1973

2. Feasibility Study of Semi-Automatic Pipe handling System and Fabrication Facility - 1978

3. Feasibility Study on Development of an Economical System for Cleaning Dry Docks Prior to Flooding - 1978

4. Requirements Report Computer Software System for a Semi-Automacit Pipe Shop - 1980

5. Beam Line Feasibility Study - 1981

6. Long Range Facilities Planning

   a. Todd Pacific Shipyards Corp.,Los Angeles Division - 1981
   b. National Steel & Shipbuilding Co. - 1982
   c. Peterson Builders, Inc. - 1982
   d. Avondale Shipyards, Inc. - 1983

PROJECTS RECENTLY COMPLETED

1.	IHI Survey of AS1 and the Development of a Long Range Facilities Plan	February-1983
2.	Pipe Shop Implementation - Phase II -	March-1983
3.	Implementation of IHI Technology at AS1	
	a. Production Planning and Scheduling	May-1982
	b. Design Engineering For Zone Outfitting	June-1982
	c. Mold Loft, Production Control, & Accuracy Control	November-1982
	d. Process,Lanes & Design Engineering	June-1984
4.	Web Line Feasibility Study	December-1984
5.	Implementation of Process Lanes	February-1984
6.	Nesting and Marking System	April-1985
7.	Crane Analysis	May-1985
8.	Metal Forming System	April-1985
9.	Fitting & Welding Cylinders	April-1985

PROJECTS IN PROGRESS

1) SP-l-83-05
Group Technology/Flow Applications in Shops - Phase I

2) SP-l-83-06
Portable Flushing System for Shipboard Piping System Cleaning

3 SP-l-84-01
Pipe Storage and Movement

4) SP-l-84-02
Feasibility Analysis of An On-Line Material Order/Delivery System

5) SP-l-84-03
Moving Personnel-h Light Material Onto A Ship and About A Shipyard

PROJECTS APPROVED FOR FY-85

1) SP-l-85-01
Comparison of U.S. and Foreign Cost for Shipbuilding Material and Components, Phase I

2) SP-l-85-02
Cost of Effective Maintenance and Repair of Air compressors

3) SP-l-85-03
Staging Systems for Ships During New Construction and Repair

4) SP-l-85-04
Evaluation of Smoke Extraction Systems versus Ventilation

MAJOR PRODUCTIVITY GAIN

SP-1 FACILITY
Manufacturing Technology
R & D By U.S. Shipyards In
Cooperation with the National Shipbuilding
Research Program

PROJECT	ESTIMATED/ACTUAL SAVINGS
o Pipe Shop	37.5%
o T-Drill	25%
o Tech (IHI)	15%
0 Process Lanes	15%
0 Beam Line	65%
o Web Line	30%

Normalized Productivity Gains
Projected from R&D Effort
Contingent on Magnitude of
New Construction Work Load

Project	Cost R&D and Implement $ Millions	Anticipated Savings $000 M/H COO	Anticipated Savings at 20.00 M/H	Savings Applied By
Pipe Shop	5.7	M/H79.6	$1.6	Ship Set
Beam Line	4.6	M/H72.2	$1.4	Year
Web Line	5.4	M/H43.0	$ -9	Ship Set
T-Drill	.2	* 288.3	* .3	Ship Set
IHI	4.2	M/H255.0	$4.5	*Year*
Process Lanes	2.2	36.0	$ .7	Ship Set

* Mixed Savings Purchased Items & Manhours.

** Implemented with Benefits being shared by customers and yard.

COST OF FIXED JIGS COMPARED TO PIN JIGS

STEEL COST -725 TONS AT 400.00	= $290,000.00
LABOR COST-	= $ 36,023.00
TOTAL FIXED JIG COST LIMITED TO SINGLE CONTRACT -	- $326,023.00
PIN JIG COST LABOR AND MATERIAL CAN BE USED FOR ALL CONTRACTS	= $175,000.00

NOTE- DOES NOT CONSIDER UPGRADE TRAINING FOR LINE HEATING BURNERS TO IMPLEMENT THE PIN JIG CONCEPT

GROUP TECHNOLOGY/FLOW APPLICATIONS RESEARCH

By

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Manager, Facilities and Maintenance

and

William S. Oakes, P.E.
Industrial Engineering Specialist

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ABSTRACT

The general subjects of GT (group technology), production cells, and shop flow have been in the technical press for some time now. And the relationship to CIM (Computer Integrated Manufacturing) is also being introduced.

All of these concepts have much to offer the shipbuilder, but we need to relate these modern concepts to shipbuilding.

In this talk, we will describe these related subjects and the opportunities that shipbuilders have, a new look at CIM and GT from a shipyard perspective, and several proposed practical projects involving a machine shop and a sheet metal shop.

As we see it, many shipyard shops are set up in "departments", grouping similar machines based on the commonality of the machines. Another way is to group machines and processes based on the commonality of the groups of products being processed.

This different viewpoint may have a lot to offer us as shipbuilders in reduced costs and faster thruput.

Synopsis

The general subjects of GT (group technology), production cells, and shop flow have been in the technical press for some time now. And the relationship to CIM (Computer Integrated Manufacturing) is also being introduced.

All of these concepts have much to offer the shipbuilder, but we need to relate these modern concepts to shipbuilding.

In this talk, we will describe these related subjects and the opportunities that shipbuilders have, a new look-at CIM and GT from a shipyard perspective, and several proposed practical projects involving a machine shop and a sheetmetal shop.

As we see it, many shipyard shops are layed out in "departments", grouping similar machines based on the commonality of the machines,

Or, even worse, sometimes our shops are not situated with any visible rhyme or reason.

Another way to lay out the shop is to group machines and processes based on the commonality of the groups of products being processed.

This different viewpoint may have a lot to offer us as shipbuilders in reduced costs, faster thruput and reduced WIP (Work-In-Progress inventory). Reductions in WIP will reduce the possibilities of lost and damaged material, especially in the Sheetmetal Shop: example shown later.

Just about all of American industry is looking for ways to improve productivity. It is not so much that we would like to make more profits as it is to survive.

An expert has been quoted to the effect that we have our choice of three alternatives:

Automate - use robots, NC, computer control
Imigrate - go offshore
Evaporate - go out of business

These suggestions don't have a lot of attraction to us as shipbuilders, although automation may have a few possibilities.

But Group Technology/Flow Lanes presents a very interesting chance to improve our production situation.

The two of us did not start our career in a shipyard but we've become quite convinced that to the traditional list of production requirements of:

1. Trained, skillful manpower
2. A producable engineering design
3. The correct level of facilities and other staff support including planning, scheduling, and material/purchasing services.

We could call out another:

4. Group Technology or Process Lanes

First let's look at some definitions:

GROUP TECHNOLOGY

An engineering and manufacturing philosophy which identifies the "sameness of parts, equipment, or processes". It provides for rapid retrieval of existing designs and anticipates a cellular type production equipment layout.

ANSI

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Slide #l

And while we're at it, here is one definition from Dick Price of Avondale Shipyards of a process lane:

PROCESS LANES CONCEPT

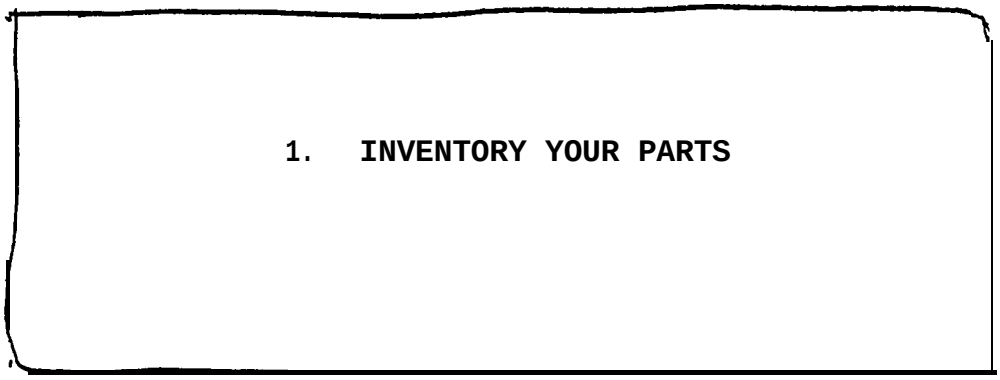
DEFINES:

THE PROCESS LANES CONCEPT MEANS VERY SIMPLY THE CATEGORIZATION AND SEPARATION OF "LIKE KINDS OF WORK", AND THE SUBSEQUENT DEVELOPMENT OF WORK CENTERS SPECIFICALLY DESIGNED TO EFFICIENTLY AND ECONOMICAI&Y PRODUCE THAT KIND OR WORR. PROCESS LANES STABLISH THE GREEATEST AMOUNT OF "LEARNING CURVE" EFFICIENCY BY HAVING THE SAME PEOPLE AT THE SAME WORK CENTERS DOING REPETITIVE TYPES OF WORE EVERY DAY WITH THE SUPPORT OF A WELL ORGANIZED AND EFFICIENT FLOW OF MATERIAL.

As you can see, these are similar concepts both aiming at a production organization that situates its production flow in such a way that we try to do all similar funtions in the same place with the same people and equipment, minimize Work In Process (WIP) I and minimize material handling. Usually when we make small parts like sheetmetal fittings we call the organization a Process Lane (1).

So you say, "Ok so far, how do I go about implementing such a system, or even determining what it would cost?"

Here's our version of the steps involved, you'll have to work out your own costs.



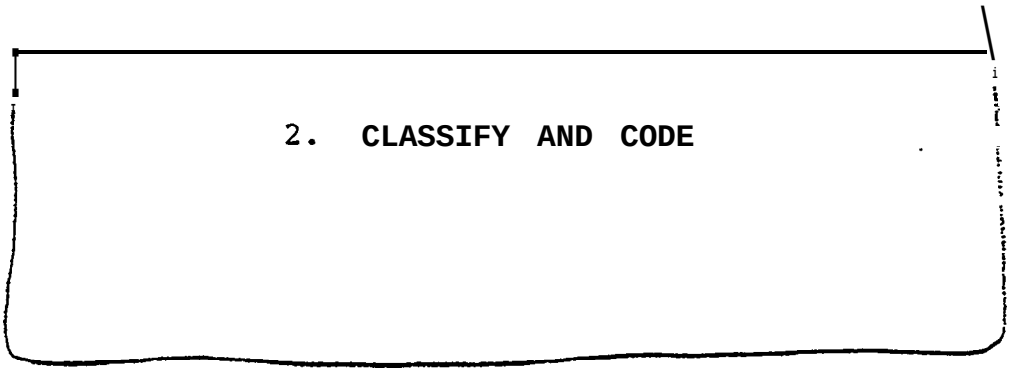
Slide #2

Likely candidates in a shipyard are:

- Sheetmetal assemblies
- Pipe pieces
- Steel units including fabricated parts (see 1).
- Machine shop components and repair jobs.

'This is a good place to involve the supervisor and shop personnel to help insure success in case you pick their area to work in, and to get their help in noting commonalities that you might not notice.

This is the step, however, where you "zero in" on your target.

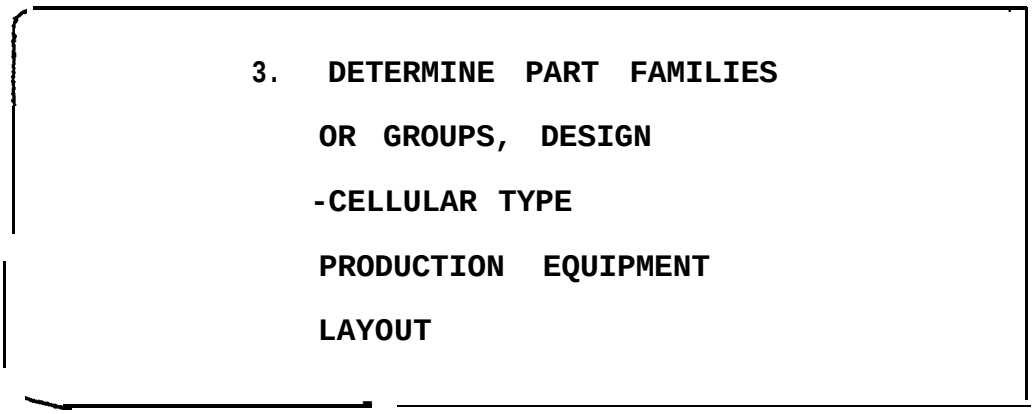


Slide #3

This step can be as simple or complex as you need or want to make it. Surely you may want to have a computer-compatible code that preserves the "group" yet allows you to code that part in such a way that computer retrieval can be achieved. This is an essential first step for a CIM system.

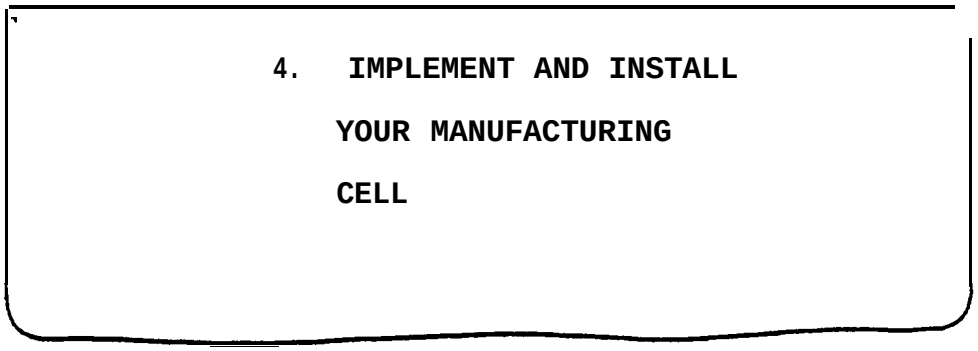
Our suggestion is that you start simple and move to more complexity as your needs develop. After all, FLANGE in our Sheetmetal Shop is a classification and a code.

The words you use should carry the commonly used local expression if possible or be easily translated in to it.



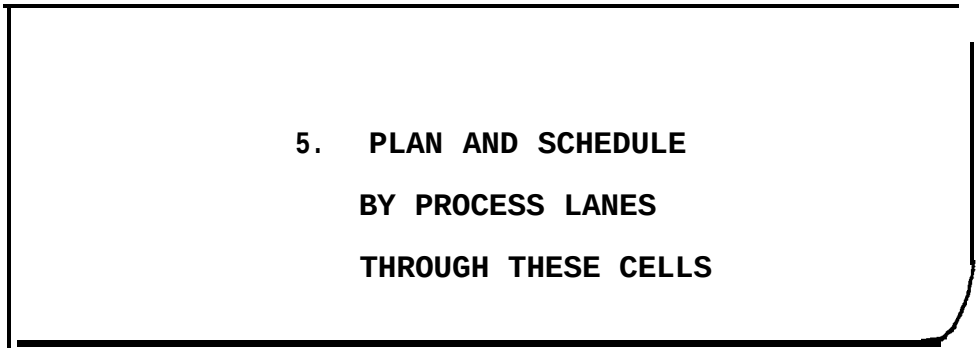
Slide #4

This step is where you get down to the hardware. It might involve combining existing equipment, purchasing new, etc.



Slide #5

After design, costing, and management go ahead here"s where you organize your cell. Involve all people that will have anything to do with the cell. If possible, get the people that will operate the cell to take part,' or at least keep them informed. This includes planning, scheduling, shop supervision and the journeymen.



Slide #6

By now it may have happened that you've noticed drawings that were not designed for producability. Go to Engineering and try to resolve' the problem. Often, the way the part was designed may act as a constraint on your production process.

6. DO YOUR PART TO
ACHIEVE DESIGN -
PRODUCTION INTEGRATION
FOR MANUFACTURABILITY

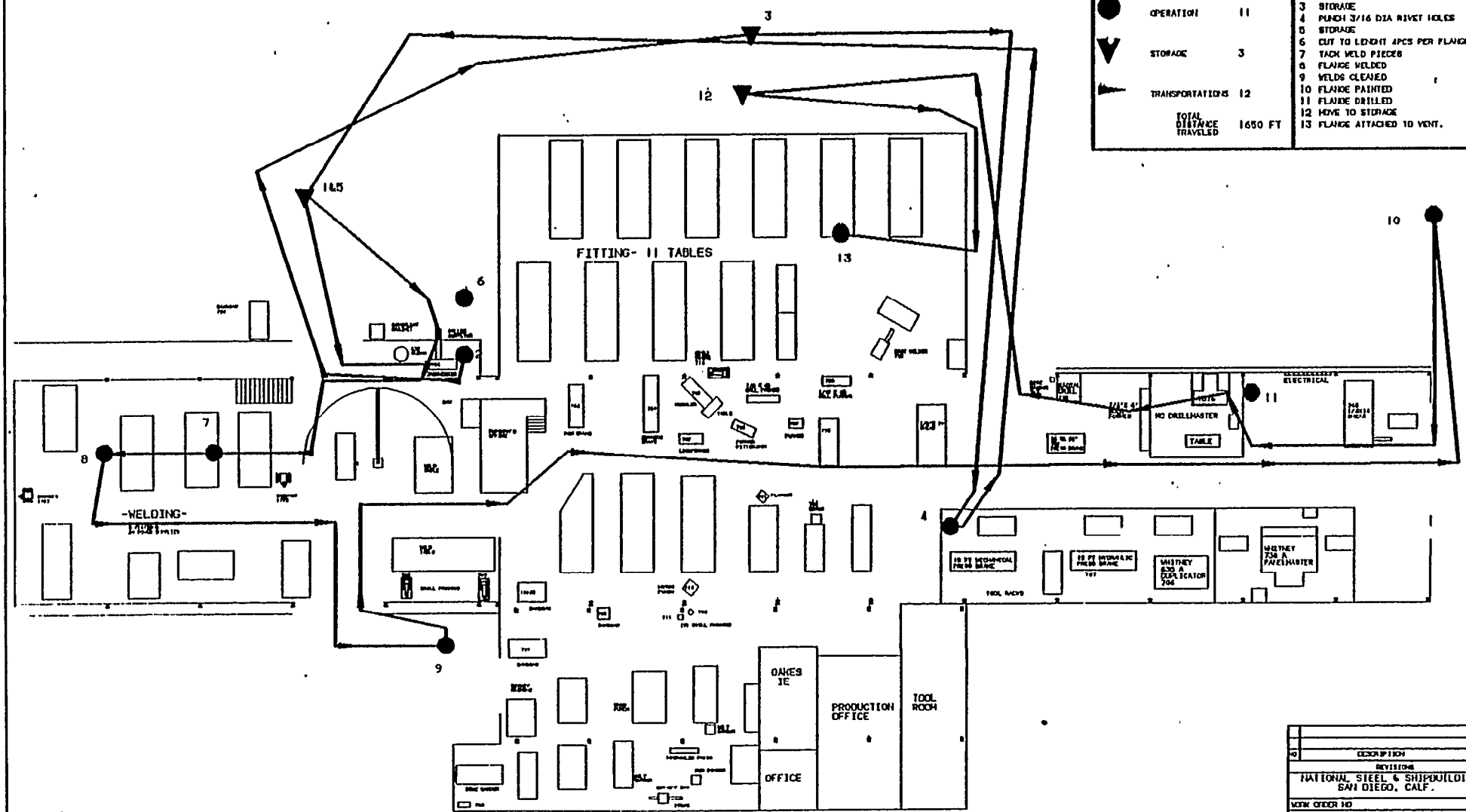
Slide #7

The next two pages show an example of one GT project at NASSCO. Most of you are familiar with the 1 l/2 x l/8 angle iron flanges that are used with most sheetmetal assemblies. Note the hodge-podge flow on the first page.

Our GT version is on the second.page. Note the simplicity.

EXISTING FLOW PROCESS FOR VENTILATION FLANGES

CHART SUMMARY		LEGEND
OPERATION	NUMBER OF OPERATIONS	1 STORAGE ANGLE IRON
OPERATION	11	2 CUT INTO 10FT LENGHTS
STORAGE	3	3 STORAGE
TRANSPORTATIONS	12	4 PUNCH 3/16 DIA RIVET HOLES
TOTAL DISTANCE TRAVELED	1650 FT	5 STORAGE
		6 CUT TO LENGHT 4PCS PER FLANGE
		7 TACK WELD PIECES
		8 FLANGE WELDED
		9 WELDS CLEANED
		10 FLANGE PAINTED
		11 FLANGE DRILLED
		12 MOVE TO STORAGE
		13 FLANGE ATTACHED TO VENT.



NATIONAL STEEL & SHIPBUILDING CO.
SAN DIEGO, CALF.

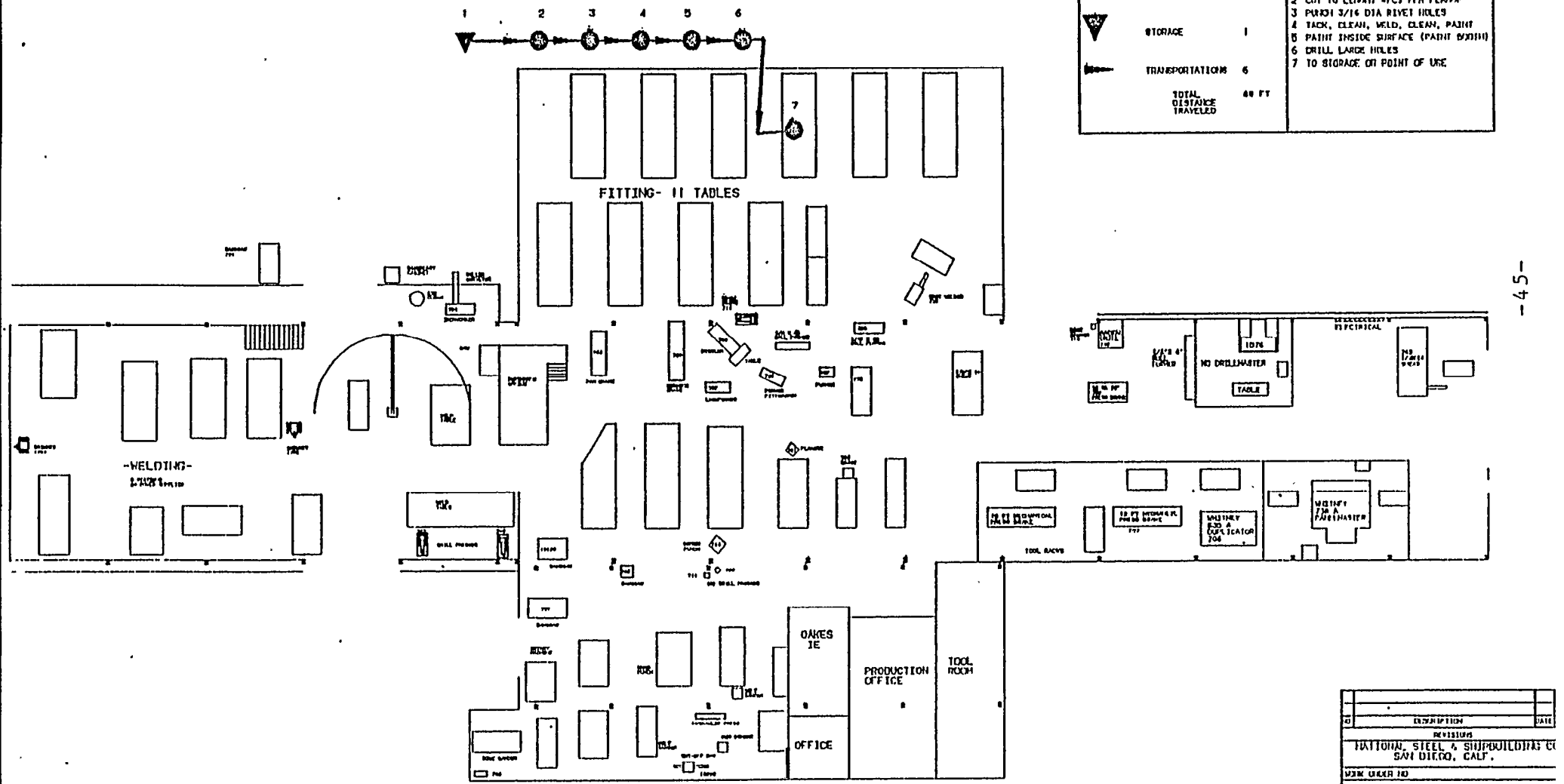
BLDG 7
EXISTING FLOW PROCESS

PROPOSED FLOW PROCESS FOR VENTILATION FLANGES

CHART SUMMARY		
OPERATION	NUMBER OF OPERATIONS	
OPERATION	7	
STORAGE	1	
TRANSPORTATIONS	6	
TOTAL DISTANCE TRAVELED	60 FT	

LEGEND

1 STORAGE ANGLE IRON
2 CUT TO LENGTH 4PCS PER FLANGE
3 PUNCH 3/16 DIA RIVET HOLES
4 TACK, CLEAN, WELD, CLEAN, PAINT
5 PAINT INSIDE SURFACE (PAINT BOOTH)
6 DRILL LARGE HOLES
7 TO STORAGE OR POINT OF USE



-45-

NO	DESCRIPTION	DATE
REVISIONS		

NATIONAL STEEL & SHIPBUILDING CO.
SAN DIEGO, CALIF.

WORK ORDER NO

BLDG 7

PROPOSED FLOW PROCESS

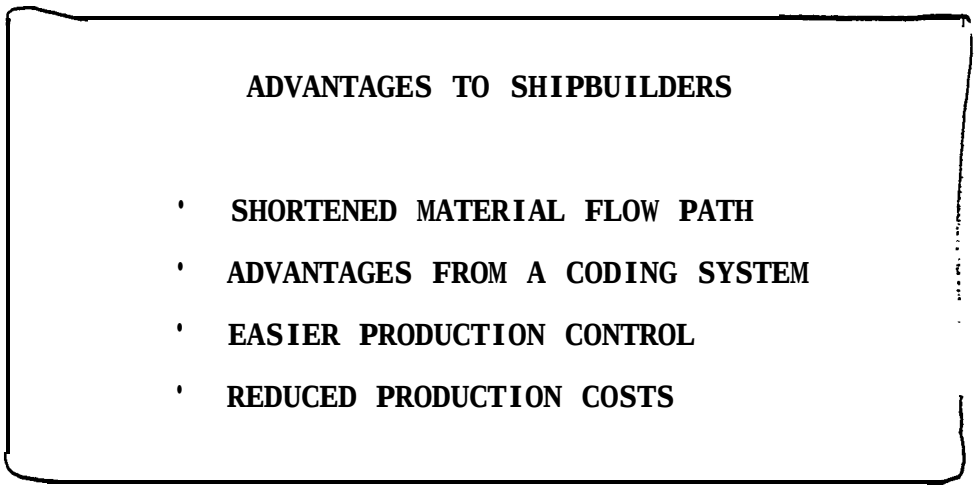
In addition to the expected higher productivity we expect to achieve:

1. Just-In-Time so that the flange is ready exactly when needed - not sooner (storage problems); not too late (holds up schedule).
2. No lost flanges. When complete they go to the assembly.
3. Reduced clutter in the rest of the shop. Right now we have dozens of flanges and parts lying around.

We have also worked up a GT/Flow Lane for the repair of butterfly globe, and gate valves.' Using the same principles outlined above, we expect:

1. Improved flow and movement of material
2. Improved processing speed
3. Closer supervision and production control
4. Increased standardization of work procedures
5. Production rate increase of 25% to 35%
6. Maintenance of flexibility

And what can you expect?



Slide #11

Caveat:

As Mr. G.M. Ranson put it in his classic Group Technology (2) " i t is all very well to have reconstructed the manufacturing scene according to G.T. with an ordered and measurable production facility, but we now require people to operate it". Watch out for proprietary feelings or reversion back to the former way of doing things.

Conclusion:

What we've talked about is just the plain old industrial engineering we all know about - applied common sense. Try it!

References:

(1) **Richard A. Price, Process Lanes Feasibility Study (U.S. Dept. Transportation, Maritime Administration, 1984)**

(2) **G.M. Ranson, Group Technology, (England, McGraw-Hill Book Company (UK) Limited, 1972)**

(3) **Society of Manufacturing Engineers, Group Technology Seminar, (Dearborn, Michigan, SME, 1984)**

WEB FABRICATION LINE

- RESULTS OF A FEASIBILITY STUDY -

By

Michael Tomzig

Sales App1ication Engineer

Oxytechnik Systems Engineering

ABSTRACT

In 1974 OXYTECHNIK designed a web fabrication system comprising equipment for mechanized handling and welding stiffeners to plates and a conveying system.' This first concept was the basis for a feasibility study to investigate the possibilities of highly mechanized respectively automatic fabrication of webs for building ships.

This paper will discuss this feasibility study: the history, requirements, result, description, special features, and conclusion.

1. HISTORY

In 1974 OXYTECHNIK designed a web fabrication system comprising equipment for mechanized handling and welding stiffeners to plates and a conveying system.
This first concept was the basis for a feasibility study to investigate the possibilities of highly mechanized respectively automatic fabrication of webs for building ships.

2. REQUIREMENTS

Conception:	Manufacturing of webs consisting of pre-cut plates and pre-processed stiffeners, conveying system connecting different StatiOnS.
Automation:	All major processes to be automated respectively highly mechanized as far as economical.
Dimensions of workpieces:	The line capable of handling webs and frames up to 54' length. max. plate width 13' thickness 5/16" to 1" stiffener length 1' to 13' stiffener height 18" stiffener type flat, T, L
Capacity:	Meeting the demands of AVONDALE Shipyards: 4 bulk carriers per year, 40.000 tons dead weight each.
Coating of plates and stiffeners:	Ability of handling coated materials respectively consideration of this influence on the welding speed, etc.

3. RESULT

- Flow production on two lanes with integrated processing stations including all activities necessary for a stand alone condition,

  two lanes for transport of webs and web frames,

- main station designed as robot for handling, positioning, and welding of stiffeners to the plate oriented in all directions as required,

- Maintaining exact location of plates after marking and cutting until transport to the welding station. Control of welding robot derived from data of plate marking and cutting process.

4. DESCRIPTION

(see 'layout no. 734.07351 A)

Station I

The pallets consisting of two carriages will be connected and prepared for loading of plates.

Station II

The pallets will be loaded and positioned by crane, marked and labeled. Also bevel cuts are performed here, if required All information will be transferred to the machine control from the main frame.

Station III

The pallets will be moved automatically to station III for simultaneous cutting on both lanes. All cut parts remain in their original location by leaving tabs.

Station IV

Joining of plates by welding tractors, if required.

Station V

Stiffeners will be removed automatically from a storage magazine attached to the machine, positioned at the correct location on the plate, pressed to the plate, and welded on both sides simultaneously. This robot is able to handle stiffeners of 3' to 12' length. Tacking is avoided.

Station VI

Stiffeners shorter than 3' are handled with a manually controlled positioner. Tacking and welding is done manually.

Station VII and VIII

Unloading and return of pallets.
In case of frames the pallets serve as support table for arranging, tacking, and welding face plates. To simplify this work face plate machines are provided, which hold the workpieces in the correct postion before manual tacking and welding.

Station IX

Turning over by crane, line heating, adding further stiffeners, welding of bottom sides of face plate and butt joints.

5. SPECIAL FEATURES

- The transporting system can be adapted to several. purposes. The normal use is for production of webs and frames as described. By joining pallets sidewise also panels up to 27' x 59' can be processed.

- All machines are arranged on same rails.

-Any handling of single cut plates is avoided reducing labour costs and production time.

- Cutting and marking information is utilized to control the robot.

- All mechanized stations require 7 operators. Manual work like turning over of plates, finishing of longitudinal welds, tacking, and welding of small stiffeners, etc. were not calculated.

- The capacity of the line can be increased by water plasma cutting.

- A material management and shop scheduling system may be developed to ensure a proper connection to the existent beam line, an optimum load, and a reliable availability of parts.

7. CONCLUSION

The feasibility study is a proposal based on specific requirements. Modifications easily can be made for individual needs. The robot as the heart of the line also can be used separately as a single station if a stand alone system including plate processing cannot be realized.

THE NESTING AND MARKING OF SHIP PARTS CUT FROM STEEL PLATE

by

HARRY HOOPER
CONSULTANT TO AVONDALE SHIPYARDS, INC.
2.20.85

Project No. A813

ABSTRACT

In this paper, the methods presently used by United States shipbuilders for preparing, nesting and marking plate parts are discussed. The use of existing computer technology is explored as a means for improving these operations by conserving plate and reducing operating costs.

As a background for the study and the conclusions, cost comparisons are offered in graphic and tabulated forms.

In the appendices, the advantages and disadvantages of the various cutting processes and plate handling methods are presented. Included, also, is a list of the basic features required in a part nesting system for the shipbuilder.

PROGRAM MANAGEMENT

This report is one of the many projects managed and cost shared by Avondale shiprds, Incorporated, under the auspices of the National Shipbuilding Research Program. The program is a cooperative effort between the Maritime Administration's office of Advanced Ship Development and the U.S. shipbuilding industry.

Executive administration and supervision were provided by Mr. E.L. James, Vice President, Production Planning, Avondale Shipyards, Incorporated; with Mr. Richard A. Price, MarAd Research & Development program manager, Avondale Shipyards, Incorporated.

Project definition was provided by the members of the Society of Naval Architects and Marine Engineers Panel SP-1 Shipyard Facilities and Environmental Effects and Mr. R.W. Schaffran, Maritime Administration, Office of Advanced Ship Develoment.

The special advisory group was made up of the - following:

Eugene Blanchard- Vice President, Production
Bob Pourciau - Superintendent; Moldloft
James Wilkens - Group Vice President, Engineering
Alan Nierenberg - Vice President & Chief Engineer
Eugene Aspuru - Manager, Plant Engr'g. b Maintenance
Don DeSalvo - Assistant Plant Engineer
Joe Taylor - Superintendent, Pre-Fabricating

TECHNICAL SUMMARY

In this report, the methods presently used by United States shipbuilders for preparing, nesting and marking plate parts are discussed. The use of existing computer technology is explored as a means for improving these operations by conserving plate and reducing operating costs.

ACKNOWLEDGEMENTS

During this study,. a number of shipyards and suppliers were visited. These are listed at the back of the report. The study also required spending many hours with others more knowledgeable in certain areas than the author. During the preparation of the work, I have been fortunate to receive willing and able assistance from all of those contacted for which I express sincere thanks.

PREFACE

Over the past 25 years, the shipbuilding industry has gone from full scale faired hull design with manual part definition and preparation to the use of computerized designs and computer assisted part preparation. During this period of growth, the equipment and the computer systems adopted have varied from yard to yard to suit the needs at the time of purchase. In addition, existing facilities and the historical mode of operation has varied-from yard to yard. -Therefore, the methods for selecting plate sizes, for nesting parts on the plate and the requirements for marking and labeling cut parts vary from yard to yard.

In preparing this report, the above has been recognized. The various factors that play a role in the final and successfully marked parts are discussed under the appropriate headings.

It is hoped that the information contained herein will not only be found interesting and informative, but that it will also be helpful in lowering costs and improving production.

INTRODUCTION

The nesting of parts cut from rolled plate has for many years been a subject of interest to the shipbuilder. Initially, during the period of full scale lofting and the manual development of shapes from the full scale loft, nesting was done manually, often on the production floor by laying out the parts on the plate. During this period, many of the laid out parts were cut by shears or by small single torch hand guided machines. The next step in the evolution of flame cutting led to the introduction of the l/10 scale loft and the production of l/10 scale templates. With these templates it became possible to produce nested l/10 scale templates where the individual parts were grouped on a scaled shape of the plate to be used. Photographic negatives of the nests were then prepared at a further reduced scale. These negatives were projected on plates fed through a dark projection tower. Operators marked the projected outline of the shapes on the plate. Using the manually marked path, the parts were cut by a manually guided, power or hand operated torch. This required large burning areas and multi-man single torch burning operations, the number depending on the ship production needs. Because of the accumulation of tolerance errors encountered, many parts were cut oversize and trimmed to fit at assembly.

With the advent of the shape cutting machine, it became possible to produce cut plate parts and, in particular, the smaller parts using a full scale paper template and one or more cutting torches, depending on the quantities of parts required.

Introduction of the electronic tracer in the 1940's made it possible to eliminate the hand guided cutting method and quite accurately cut parts from full scale templates with an automatically guided template scanning device.

In the 1950's, it became possible to operate large coordinate driven flame cutting machines from l/10 or smaller scaled templates. This was accomplished through the use of pilot machines equipped with photoelectric tracing heads that followed the l/lOth scaled templates or scaled projections of the original photo negatives. Here again, through the manual arrangement of parts on the scaled plate shape, it was possible to create a nest that improved plate utilization.

In the mid 1950's, the numerical control of machine tools became practical, first with positioning devices and then with contour following devices. Programs for these devices were originally prepared manually and the necessary punched tape was prepared by a manuale punching device and later by special typewriter machines.

As the numerical controls and machine hardware improved, manual programming became impractical and industry identified a growing need for the development of computer programming and the associated hardware. Because of the initial cost of N/C controls and the associated hardware and the lack of software, the application of N/C to shipbuilding took hold slowly. Initially, some users of the equipment, because of the lack of computer software for defining shapes, operated from scaled drawings. Tapes were prepared from these drawings -through the use of point to point digitizers. Even today, some yards continue to use paper templates and digitizers for some of their programming needs.

Through the years, there has been steady improvements made in the machine hardware, in the N/C controls and in the associated program software.. This has led to the use of powerful high speed servo drives on the cutting machines. This, in turn, has led to a speedup **in** production through the use of the plasma cutting process and the accurate high speed plate marking at 200 to 300 IPM.

During the past few years, developments achieved through the use of mini-computers and main frame computers have further enhanced the performance of machines and associated equipment to the point where some advanced systems operate from DNC (Direct Numerical Control) and the use of punched tape has been completely eliminated.

These developments have created an environment requiring improved nesting and marking technology. This report has been prepared to help identify the problems and to help pave the way to both time and material savings through the use of efficient, computer-oriented methods for nesting, marking and coding of flame cut parts.

DISCUSSION

CLASSIFICATION OF PARTS CUT FROM STEEL PLATE.

The steel lift for ordering plate is usually prepared by the engineering department. When preparing this list, preliminary nests of the parts required are usually made. These parts fall into three general classifications as follows:

Class 1 - These are the large parts that may be cut in direct image mode or both direct and mirror image modes. On these parts some layout marking is usually required for referencing them to other parts on the ship's hull. In most shipyards today, these parts are cut and prepared by large numerically controlled cutting machines.

Class 2 - The low quantity smaller parts such as intercostals, web frame sections, equipment mounting brackets. etc.

Class 3 - The high quantity small parts such as brackets, clips, collars and chocks that are used throughout the construction of the hull.

These three categories can be divided into area groupings of the total plate used with the following approximate values:

Class 1 - 72%
Class 2 - 24%
Class 3 - 4%

These three categories of parts will be further discussed ***in*** the following sections on the nesting, cutting and marking of cut plate items.

CUTTING WITH THE OXY-FLAME PROCESS.

When using a large N/C flame cutting machine and the oxy-flame process, it would take 130 minutes to cut the parts shown in Fig. 1 giving a yield of 84%. The total process time would break down as follows:

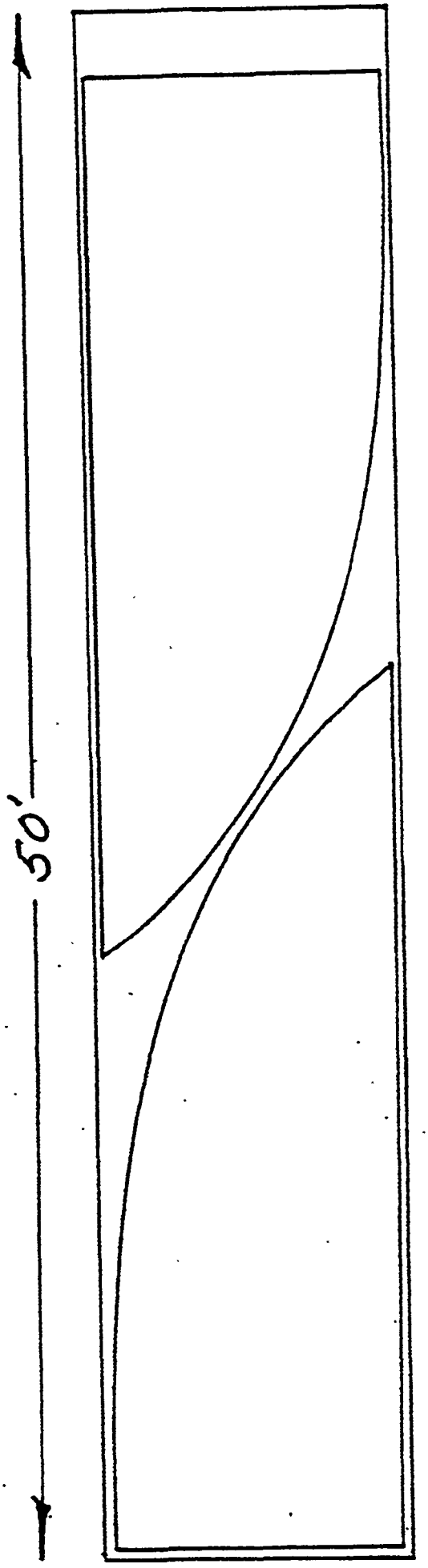
Plate handling time	- 15 mins.
Plate marking	- 10 mins.
Cutting time	- 130 mins.
Part and scrap removal	- 15 mins.
Total time	- 170 mins.

When adding Class 3 parts to the nest as shown in Fig. 2, the yield increases from 84% to 89%. The cutting time would increase from 130 minutes to 250 minutes and the total process time, including marking and handling, would become 346 minutes or about double the time required in the first case. (See Fig. 3). Here the scrap saving, valued at approximateiy $105.00, when weighed against the reduced production of the machine might be questioned. See Fig. 4 for the dollar value of the steel. This helps explain why the production of flame cut parts in many shipyards today is as follows:

Class 1 and most Class 2 parts are produced by the large numerically controlled machines, which not only produce accurate parts, but which also do the plate layout marking automatically. The Class 3 parts are produced in general by any one of the five following methods which include:

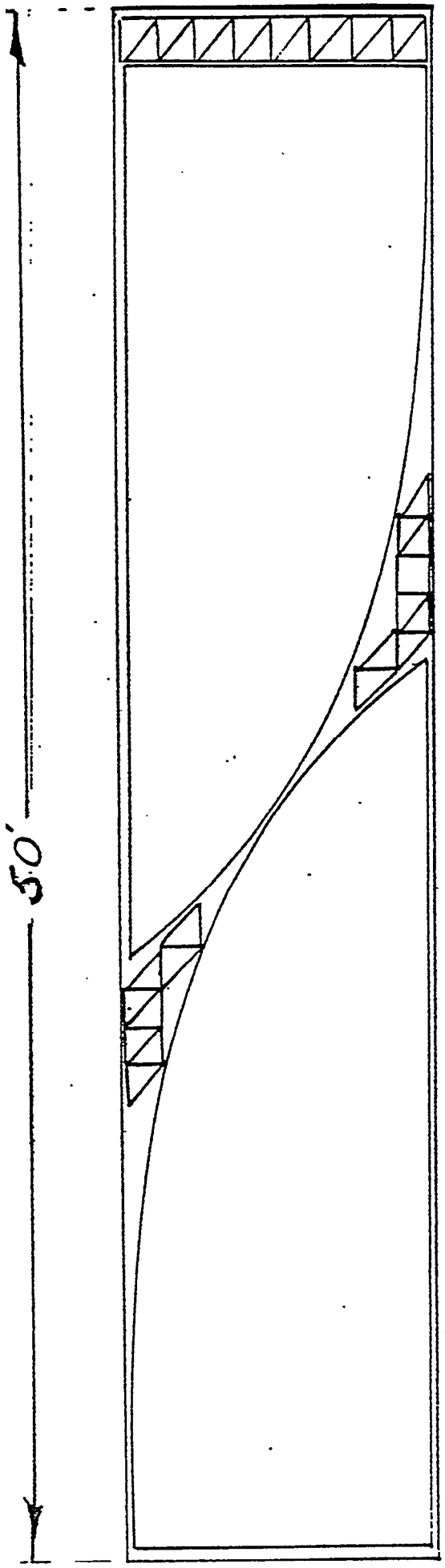
1. Flame strip and shear.
2. Flame cut by multi-torch machine with optical template scanner.
3. Flame cut by multi-torch machine with numerical control.
4. Plasma cut by single torch machine with numerical control.
5. Manual layout and use of single torch manually guided machines.

With all but 3 and 4 above, these methods require a paper template, a wooden template or a manual layout.



YIELD: 84%

TYPICAL PART
CUTOUTS NOT SHOWN



YIELD 89%

Fig. 2

PROCESS TIME FOR PRODUCING PARTS SHOWN ON FIG. 1 AND FIG. 2.

A. Flame Cutting and Paint Stick Coding:

Operation	Fig. 1 time - mins.	Fig. 2 time - mins.
Plate handling	15	15
Plate Marking	10	30
Cutting time	130	250
Part and scrap removal	15	37
Total time	170 mins.	332 mins.

B. Plasma Cutting With paint Stick Coding:

Plate handling	15	15
Plate marking	10	30
Cutting time	22	40
Part and scrap removal	15	37
Total time	62	122

C. Plasma Cutting With Label Coding:

Plate handling'	15	15
Plate marking	10	16
Cutting time	22	40
Part and scrap removal	15	37
Total time	62	108

Fig. 3

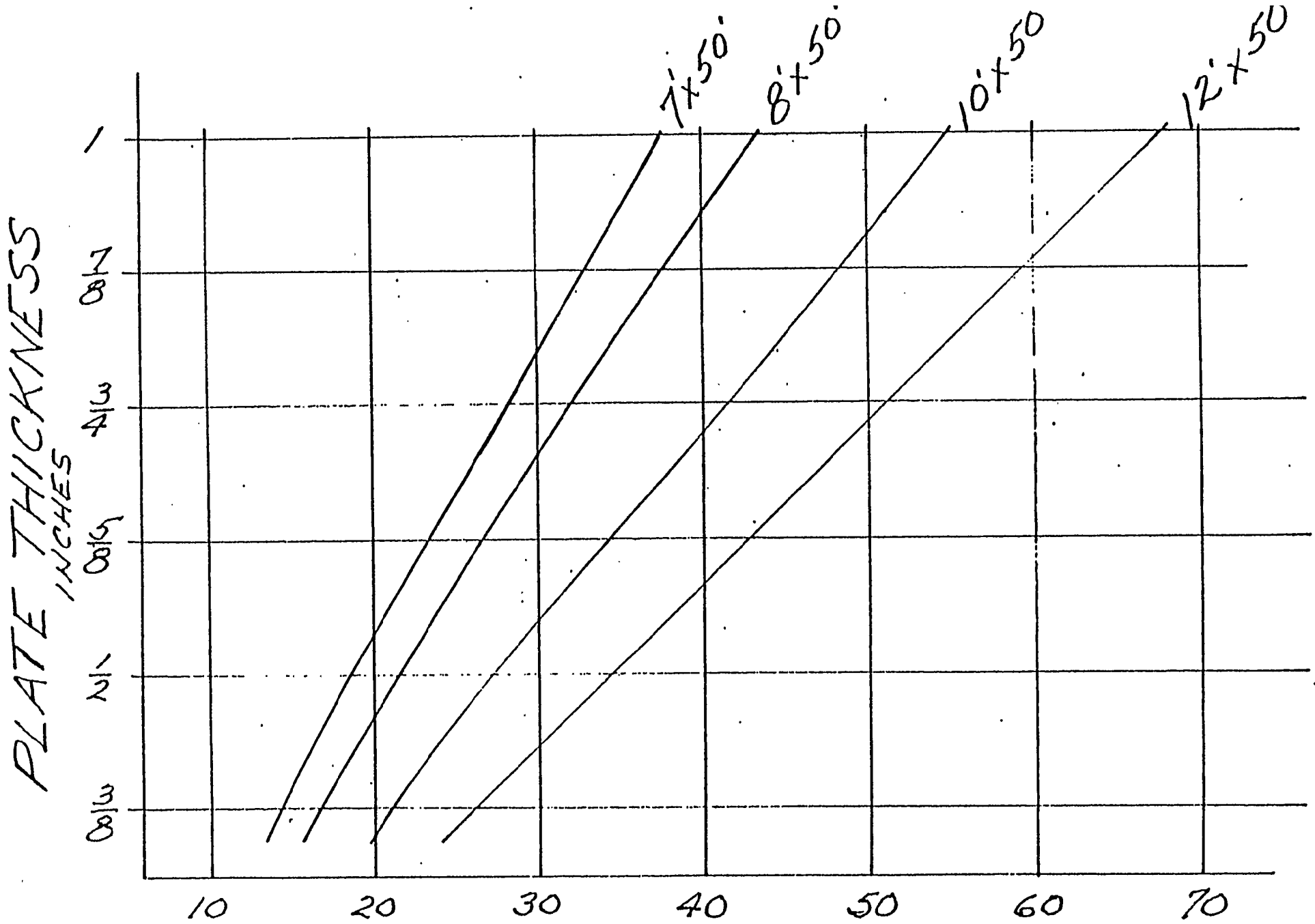


Fig 4

APPROX. DOLLAR SAVINGS FOR EACH % INCREASE IN PART YIELD FROM CARBON STEEL PLATE (MAT'L ONLY)

On Fig. 5, the results of a time study for producing brackets by each of the above methods is listed. Usually. the material used to produce these Class 3 parts is the drop-offs from the large N/C machine or machines. In the study; the material cost indicated is for new plate.

The advantages and the disadvantages experienced with the use of the oxy-flame cutting process are listed in Appendix 1.

CUTTING WITH THE PLASMA PROCESS.

During the past several years, the advances made in the development of both hardware and software have made it possible to very effectively produce steel ship parts with the plasma cutting process. See Fig. 6 for cutting speed comparisons.

When using the plasma process for cutting the nests shown on Fig. 1 and Fig. 2, the time required is reduced considerably as shown on Fig. 3. Through the use of the plasma cutting process and a good part nesting , significant savings can be realized in producing a mix of Classes 1, 2 and 3 parts as shown on Fig. 7.

The advantages and disadvantages experienced with the use of the plasma cutting process are listed in Appendix 2.

NESTING CLASS 3 P-ARTS USING NUMERICAL CONTROL.

At present, in many shipyards, most Class 3 parts are cut through the use of templates. To include these parts in an N/C nesting program would require numerical control program preparation and the elimination of template use. To effectively use these programs, the smaller flame cutting machines, now equipped with optical template scanners must be equipped with CNC controls. The CNC controls used should be capable of

RESULTS OF MATERIAL AND TIME STUDY FOR PRODUCTION OF 136 - 14" x 14" x l/2" STEEL BRACKETS.

	METHOD	YIELD	LABOR COST	MATERIAL COST	TOTAL COST
1.	Flame strip* and shear.	95%	$ 65.50	$ 551.00	$ 616.50
2.	Flame cut using four torches and optical scanner.	65%	62.50	806.15	868.65
3.	Flame cut using four - torches and CNC.	85%	53.75	616-47	670.22
4.	Plasma cut using one torch and CNC.	85%	53.25	616.47	669.72
5.	Manual layout, flame cut using track machine.	90%	543.00	582.22	1,125.22

Coding by paint stick method included in above - $ 14.44

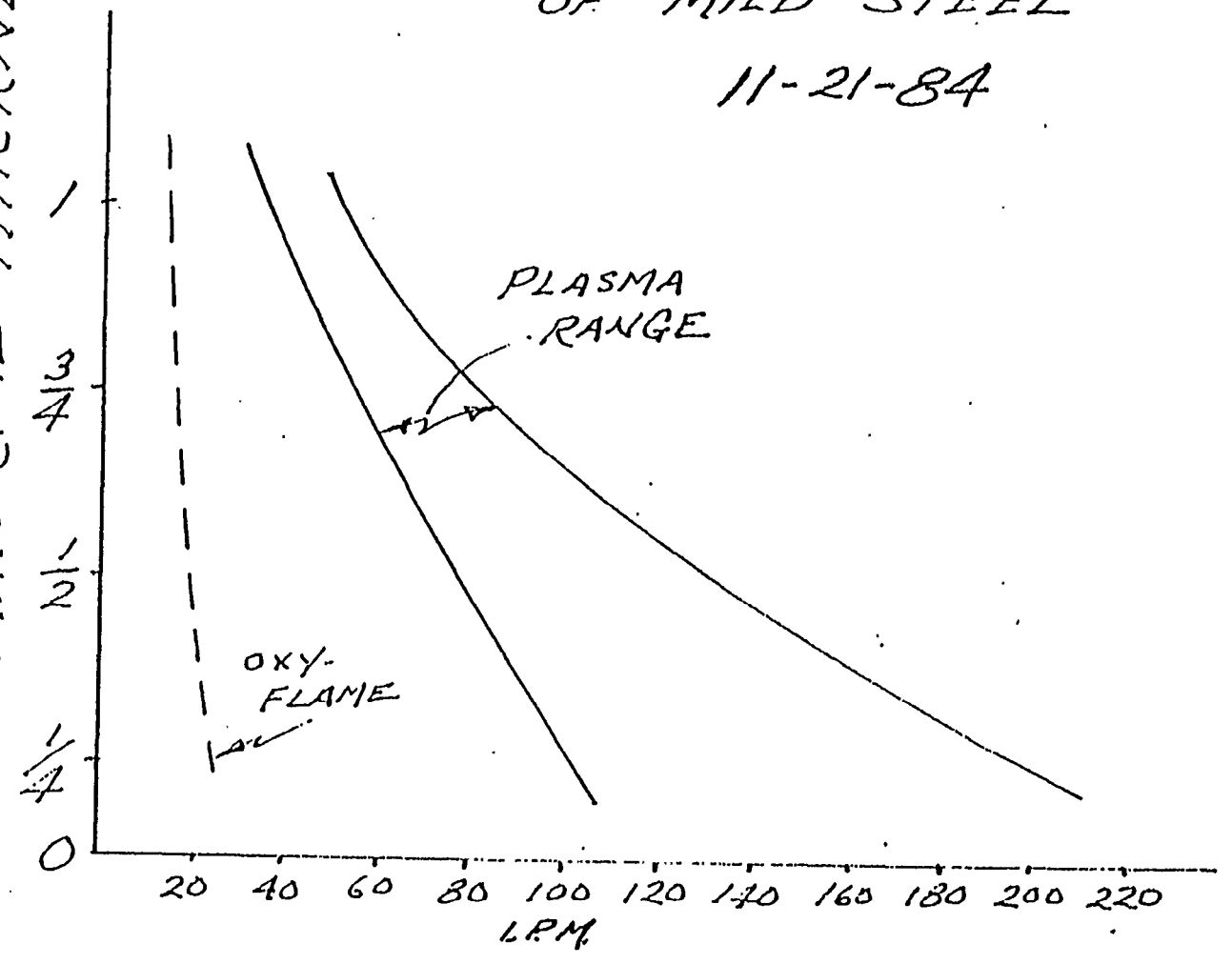
Coding by DNC label - $ 3.78

*Limited to straight line cutting only.

Fig. 5

APPROX OPERATING RANGES
OXY-FLAME & PLASMA CUTTING
OF MILD STEEL

11-21-84



AVERAGE LABOR AND MATERIAL COSTS FOR PRODUCING' A TON OF FLAME CUT PARTS FROM l/2" STEEL PLATE.

	Labor		Material - yield		
	Oxv-flame	Plasma	80%	85%	90%
Class 1 parts 72%	$ 8.43	$ 3.79	$473.40	9445.55	$420.80
Class 2 parts 24%	4.90	1:82	157.80	148.52	140.2
Class.3 parts 4%	7.60	3.47	26.30	24.75	23.30
Totals: 100%	$20.93	$9.08	$657.50	$618.82	$584.4:

NOTE: These figures are to be considered for comparison, only, and may-vary from yard to yard. They are presented to indicate the relative value-of a good nesting system for producing a high yield of parts per ton of steel purchased

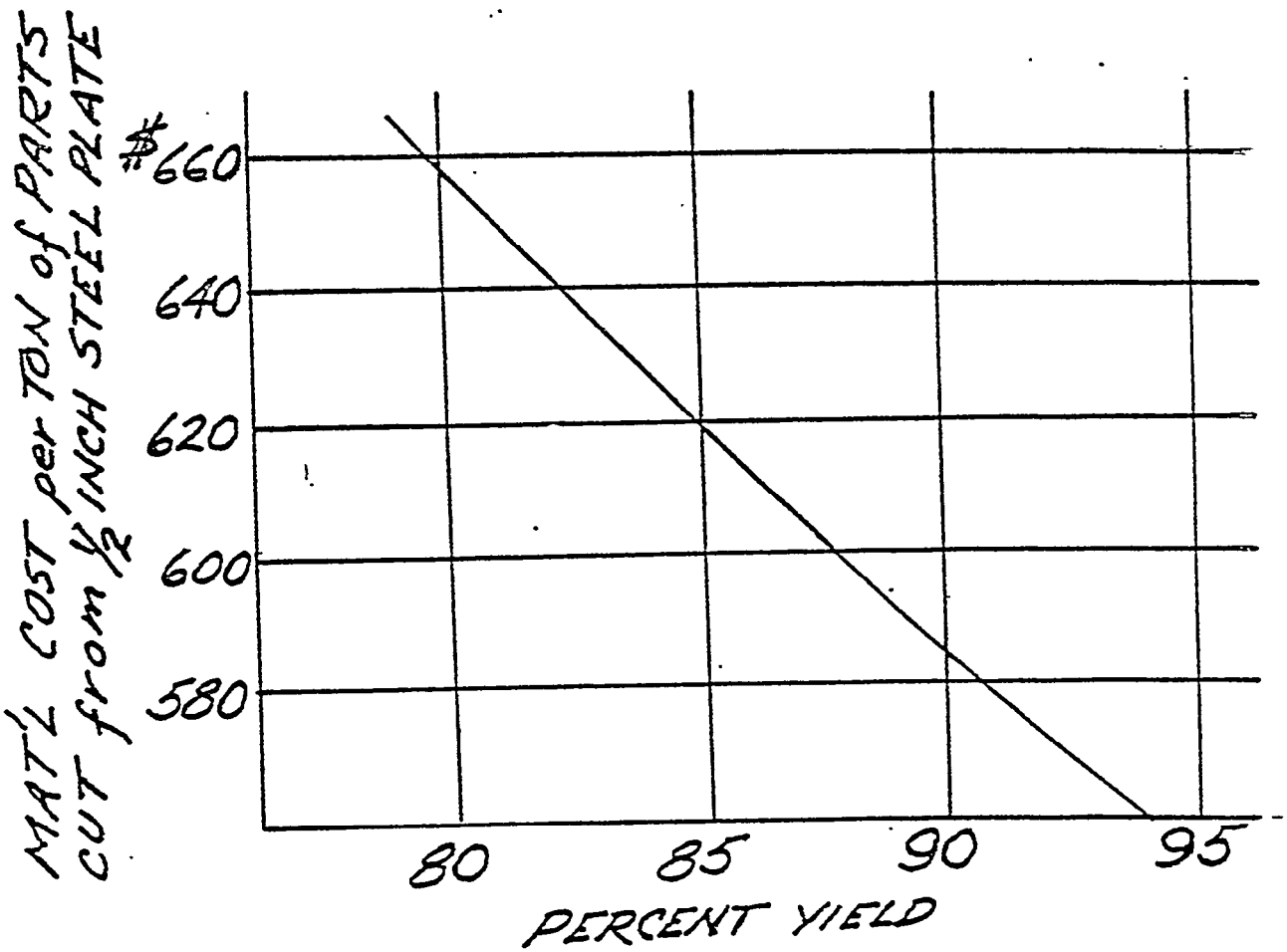


Fig. 7

accepting the same input programs that are used on the large machines. This input should be by punched tape or preferably DNC (Direct Numerical Control) as shown on Fig. 8. By so doing, any of the parts not included in the major machine nests, could be included in the nest assigned to a secondary machine. In addition, the flexibility would allow the major portion of the nest to be executed on the large machine and the remainder carried out on the smaller machine. An example of this is shown on Figs. 8 and 9.

THE USE OF STANDARD SIZE PLATES VS. SPECIAL SIZED PLATES.

Today, construction. by unit is accepted practice in the building of ships in the United States. In the interest of controlling inventory and yet providing the parts as they are needed, the parts are cut only as they are required. This procedure sometimes places some restraints on the nesting efficiency possible because of the limited number of some parts needed. Some yards, when preparing the steel lift requirements, follow a preliminary nesting procedure, from which the plate sizes to order are determined. Others orient their steel lift requirements around a limited number of standard sizes. When doing so, an attempt is made to select those sizes that will result in a minimum of welded joint footage without introducing stress or other problems in the hull assembly. Still others use a mixture of specidl sizes and standard sizes.

One yard visited made a study of plate yield over a one year period. The results of their study indicated that as the use of standard sizes increased, the yield decreased. This is a difficult subject to work with because an increase in plate yield does not necessarily point to a reduction in production costs .- If the system is not properly analyzed and time balanced, efforts made to increase the plate yield could outweigh

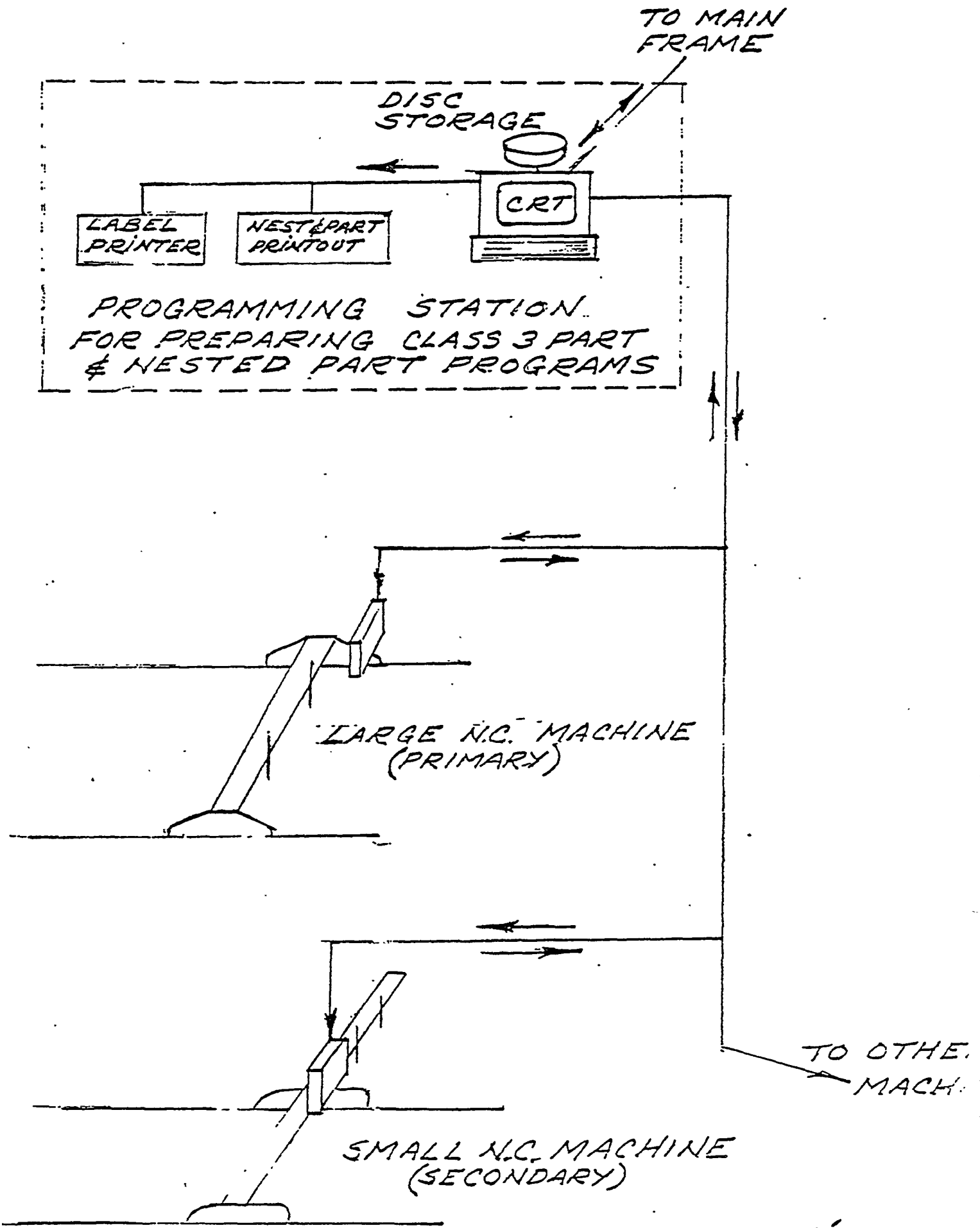

TO MAIN FRAME
DISC STORAGE
CRT
LABEL PRINTER
NEST & PART PRINTOUT
PROGRAMMING STATION FOR PREPARING CLASS 3 PART & NESTED PART PROGRAMS
LARGE N.C. MACHINE (PRIMARY)
TO OTHE MACH
SMALL N.C. MACHINE (SECONDARY)

Fig. 8

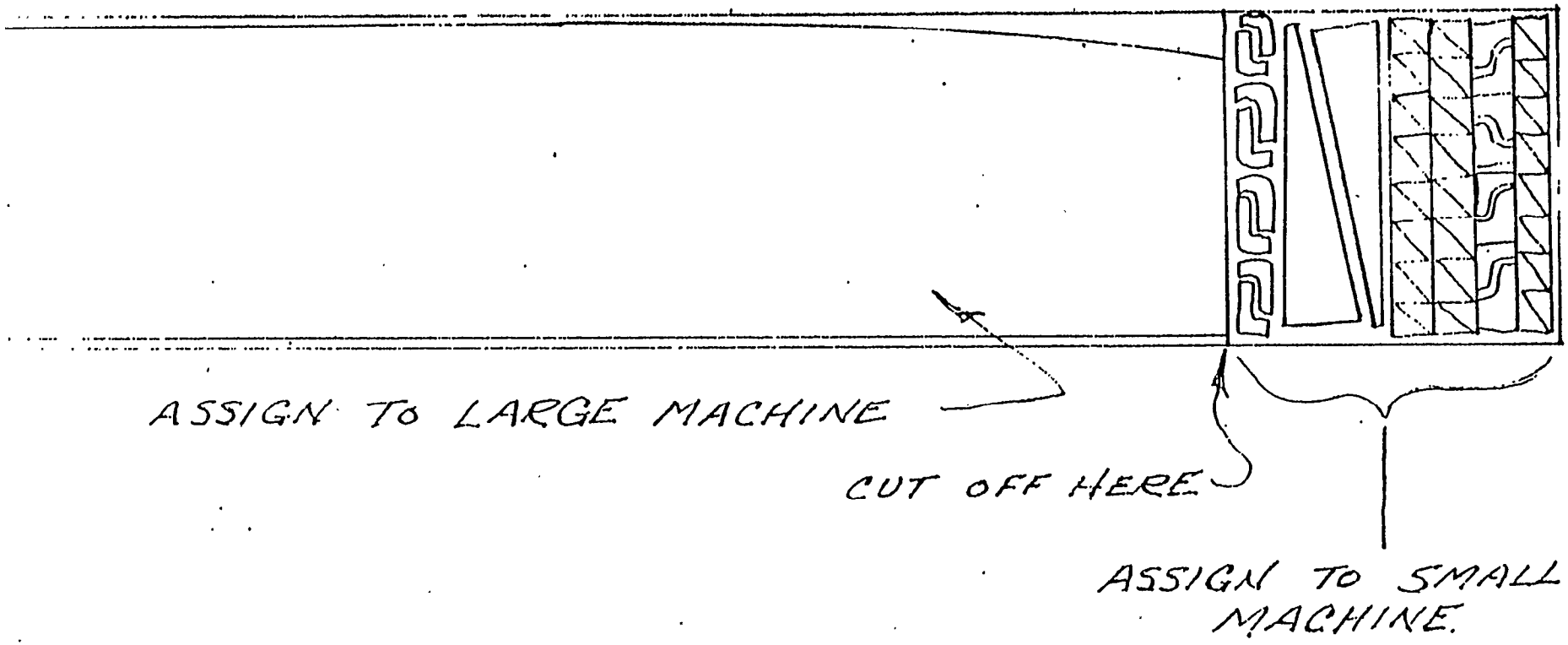

ASSIGN TO LARGE MACHINE
CUT OFF HERE
ASSIGN TO SMALL MACHINE.

Fig. 9

the savings in plate costs by an increase in labor costs and time delays. The advantages and disadvantages realized with the use of standard and special sized plate are listed in Appendix 3.

THE HANDLING OF CUT P-ARTS AND SCRAP.

The machine cutting and marking time and the method used for on-loading plate and off-loading parts and scrap plays an important role in the overall cutting operation and the nesting method employed. For cutting the Class 1 and Class 2 (Pg. 9) parts, a double cutting table arrangement that allows for side by side and end to end plate placement is quite popular. This arrangement and the use of multi-magnet lifts allows for operation over one double setup while unloading and reloading on the second double setup. Thus the cutting machine's duty cycle is increased since it can be kept busy cutting during the unloading and loading operations.

When using the oxy-flame cutting process, the nesting of small Class 3' parts with the larger Class 1 and Class 2 parts is often considered impractical because of the time imbalance encountered. See Fig. 3. Usually, in an operation of this type, the plate drop-offs are moved to a staging area for use on smaller machines for fulfilling the Class 3 part requirements. If the remnant is small in area or very irregular in shape, it is often scrapped. Where the remnant is used and the Class 3 parts are cut on a template guided flame cutting machine, the yield is often less than 50%.

To increase the available machine cutting time, some yards use removable plate supporting trays. Here the cut parts and scrap are removed at one time and deposited in a staging area 'where the scrap and parts are dealt with. The trays are then reloaded for return to the cutting machine's work table. With this method, additional floor space is required for accomodating the trays.

Where access to the machine cutting area does not allow for overhead crane loading and unloading, the use of movable cutting tables is one solution used. At the end of the cutting and marking operations, the table is moved into a staging area for further processing. When the parts and scrap are removed, the table is reloaded and circulated back to the machine for the cutting and marking operations.

Very often, 'the amount of small parts produced on the automatic N/C machines is very limited so that the machine can meet the large part assembly requirement of the yard. This often is done at a sacrifice in efficient plate utilization. By implementing the machine arrangement shown on Figs. 8 and 9, this problem can be solved and greater efficiency realized.

NESTING BY COMPUTER AND COMPUTER ASSIST.

Computer oriented nesting systems can, in general, be divided into two types. The first is known as "Interactive Nesting" which is a semi-automatic system. It involves the use of a CRT screen, a cursor and a keyboard. Parts are called up from the computer data base and are moved and rotated by keyboard or cursor input to form a desirable nesting arrangement in the plate area shown on the screen. A bump feature allows for the automatic spacing of the parts to 'a predetermined amount. Other automatic features usually include:

1. Automatic blowup enlargement for examining intersecting lines and possible overlap.
2. Sequential numbering for part identification.
3. Marker and cutter sequence by cursor or keyboard control.
4. Automatic printout and storage of the completed nested programs.
5. Inventory countdown so that parts are not unnecessarily duplicated:

The second type of computer nesting is an automatic system where the plate size and the parts to be nested are keyboard identified. By keyboard request, the parts are automatically nested and identified by sequence number. With systems of this type, the final nest is stored under an assigned number and a hard copy printout provided.

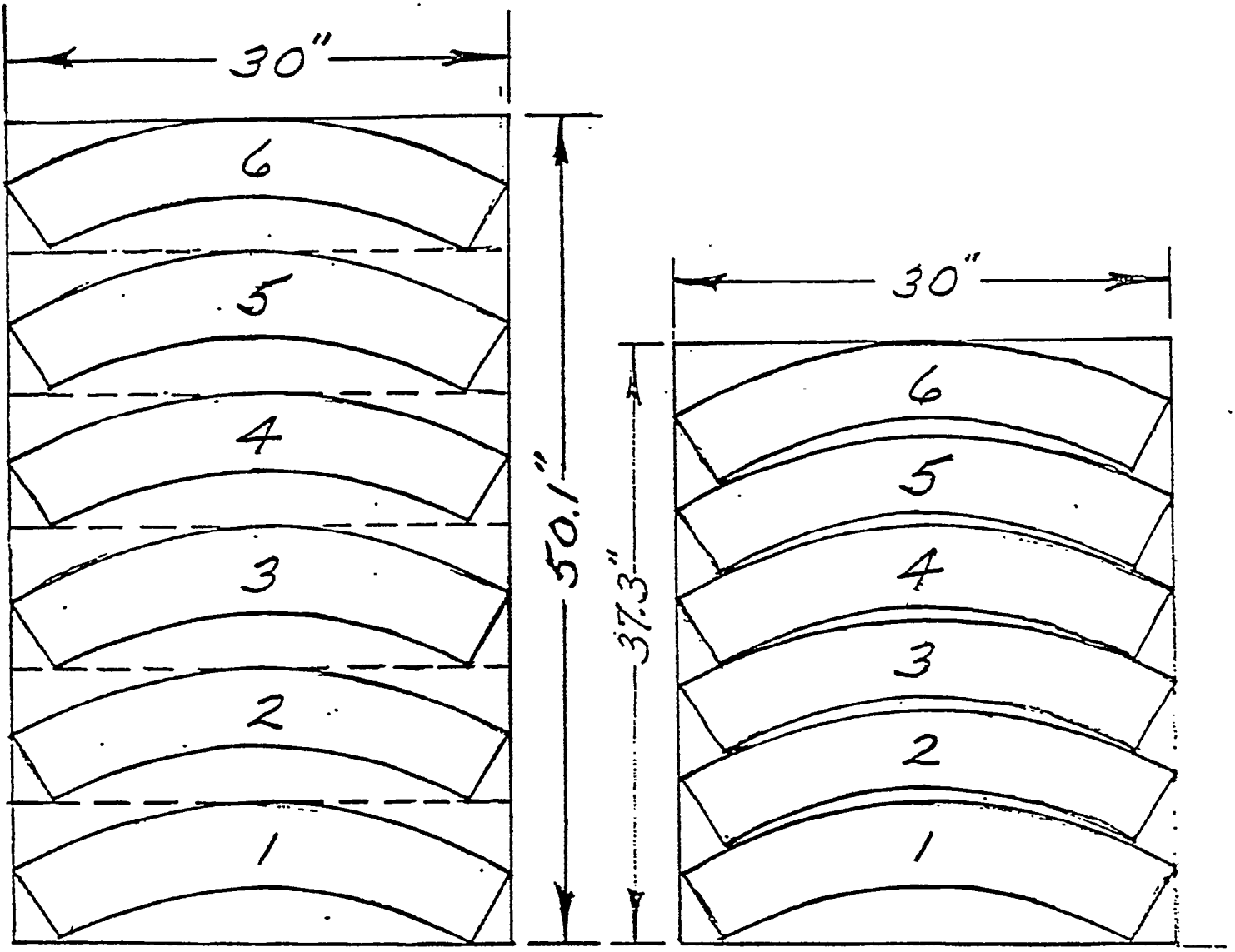
The most popular algorithm used by systems available today involves the surrounding of the part to be nested by a rectangle and rotating it so that its longest side is parallel to the x or Y axis in the program. See Fig. 12. Part nests prepared with the rectangular fitting method can easily be recognized because adjoining parts do not overlap into the arc or other concave areas as shown on Fig. 10.

Interactive nesting lends itself well to parts included in categories 1 and 2 mentioned earlier in this report, and where special sized plates are used.

Automatic nesting lends itself well to parts included in categories 2 and 3. To allow for efficient plate utilization where rectangular nesting is used, the individual part programs being nested should be grouped into two or more parts. closely representing a rectangle in shape and stored in this form as shown in Fig. 1.

Other more complex nesting algorithms are available that result in a denser part arrangement. Fig. 13 illustrates the results of part nesting using such a system. Implementing nesting systems of this type usually requires that the part program be generated on a satellite computer or main frame computer and down loaded to a satellite programming station for the part nesting and machine program assignment. In addition to the nesting capabilities, program stations available today allow for part program and CAD-CAM (computer-aided design and computer-aided manufacture) development of parts.

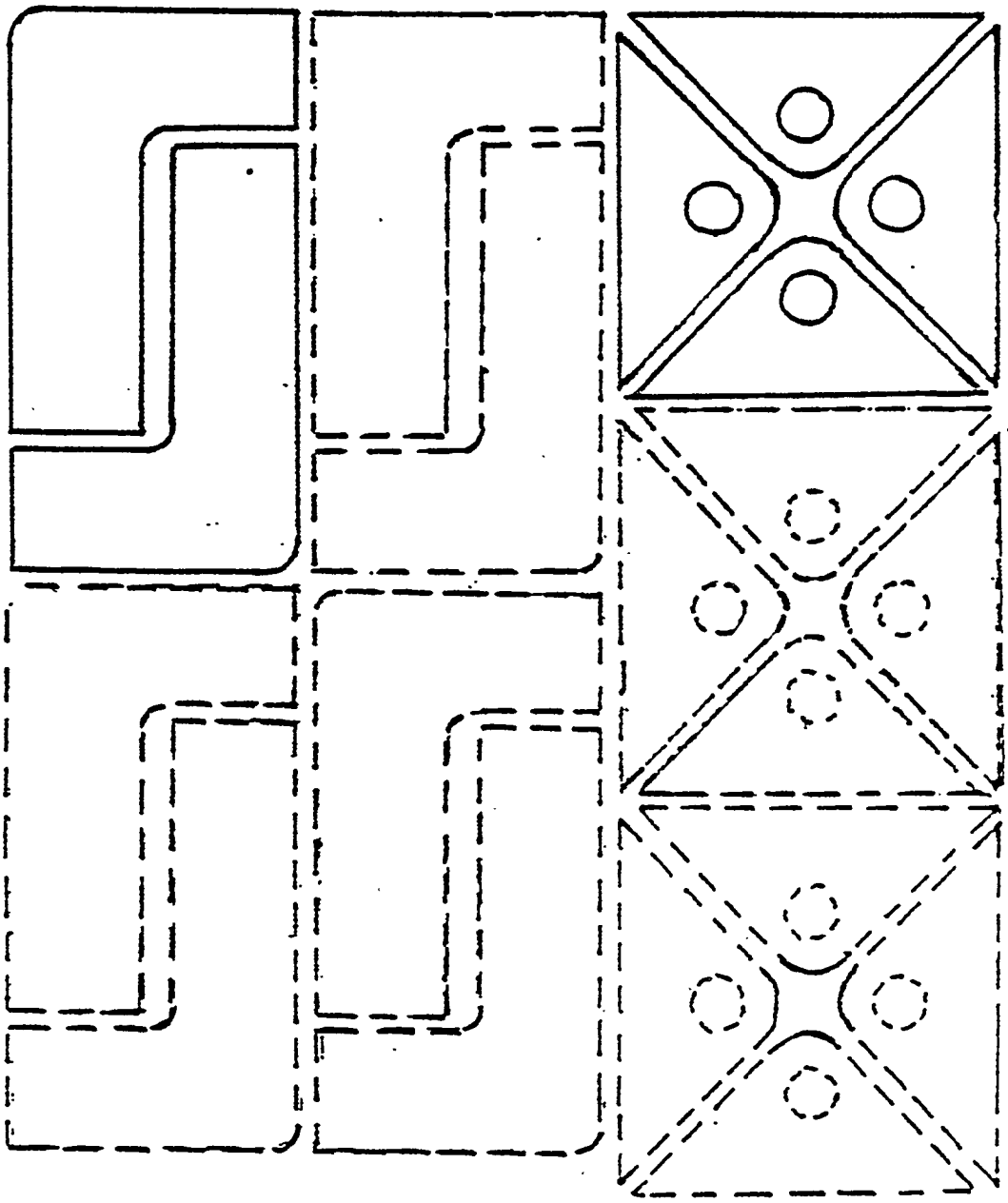
Regarding the use of computers, there are different schools of thought concerning how they should be applied to the complete operating system. One school believes there should



Examples:

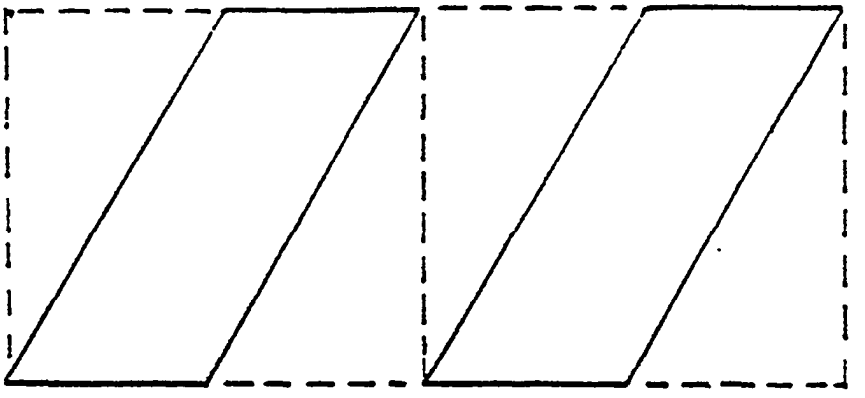
Nesting of Ring Segments by Rectangular Fitting and Interactive Graphic Methods.

Fig 10

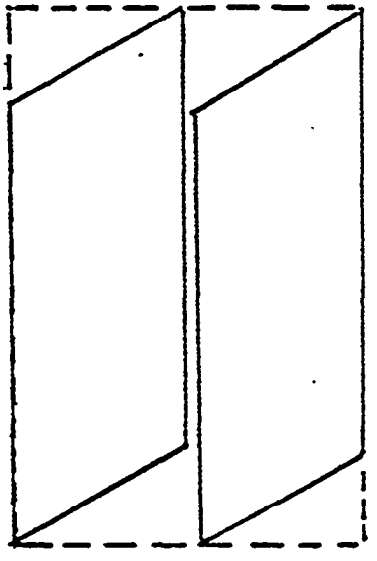


GROUPED PARTS FOR NESTING
BY THE
RECTANGULAR FITTING METHOD

Fig. 1



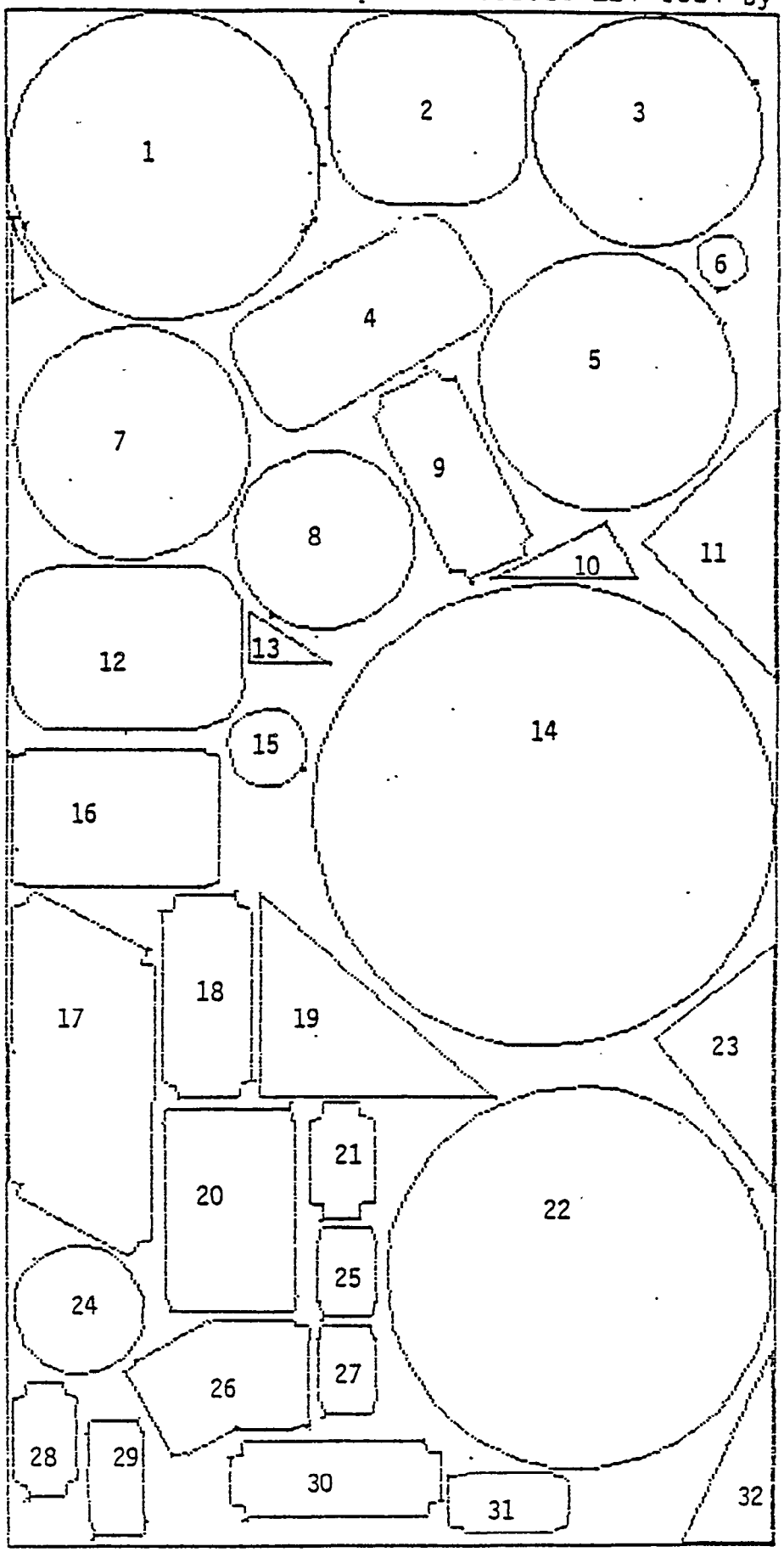
47%



77%

EXAMPLE: PART ROTATION FEATURE USE IN NESTING BY RECTANGULAR FITTING METHOD TO IMPROVE EFFICIENCY OF YIELD

Fig. 12



Percent Used: 85.5

EXAMPLE: COMPUTER NESTED by OTHER THAN RECTANGULAR ALGORITHM.

FIG 12

be one main frame computer for controlling all systems of operation. By so doing, the following advantages are claimed:

1. There is one main source of basic data information and hence a minimum of error introduction.
2. Changes in design and information update automatically reflect in the computer data output.

The disadvantages realized, however, include the following:

1. Computer downtime may render all systems inoperable.
2. As the computer system grows in complexity, software problems grow and become increasingly more difficult to cope with. This is particularly true with changes in personnel. There are many ways of constructing the mathematical approach and the solution sequence of the formulas used in software derivation. In addition, overlaps or ommisions in the software are often not uncovered until after many hours of use. Unless the person attempting to solve a problem is fully aware of the approach taken by the author, a satisfactory solution to the problem becomes very difficult to solve.
3. A computer, regardless of its capacity, sometimes is called on to solve complex, time consuming problems. As more and more demands are made on the main frame computer, and the job priorities change, its response time can grow slower to the point where it can result in a production slowdown. This could cause a cost increase that could exceed the planned dollar saving in material and process time.

There is a growing trend today to the use of one main frame computer for the basic data base information and an array of smaller computers for setting up and carrying out the detailed assignments as shown in Fig. 8. The advantages of such a system are:

1. Basic data requirements can be called down and stored on a disc in off time and held in readiness for rapid processing as required.
2. Main frame computer downtime does not necessarily affect the operation and hence operating time is minimized.
3. Software problems become local problems that can more readily be handled and solved.

4. New computer production processing methods available from various suppliers can be more readily implemented.
5. The use of one main frame and an array of satellite computers today could be more cost effective since it offers greater overall computer capacity for a lower capital investment in some cases.

A specification entitled, BASIC FEATURES REQUIRED IN A PART NESTING SYSTEM FOR THE SHIPBUILDER, is included in this report. See Appendix 4.

THE MARKING AND CODING OF PARTS.

In the production of plate parts for ship construction, each part produced requires identification marking. Many of the parts also require location marks for referring them to mating parts. In this report, identification marking is referred to as" coding" and dimensional marking is 'referred to as "plate marking". These are two distinct and different operations and in this report will be discussed as such.

Plate Marking by Air Activated Center Punch.

Most large flame cutting machines controlled by CNC in the U.S. today are equipped with plate marking equipment. The most popular type used is the air activated center punch. It consists of an automatic air activated center punch that is located on the flame cutting 'machine's torch carriage. it is usually located a fixed distance behind the center of the cutting torch's nozzle. By locating the marker behind the cutting torch in the direction of the long axis, the resulting marks are correct whether the machine is cutting in the direct image or mirror image mode. When used, the marker is automatically brought into the torch plate position for the marking operation by a fixed offset amount. while the center punch type plate marker offers many desirable features to the

user, it does have some disadvantages such as:

1. Maintenance costs are relatively high because the parts wear and require repair or replacement to maintain accuracy.
2. The operation is noisy.
3. The automatic center punch cannot effectively be used for applying numbers or letters to the plate parts.

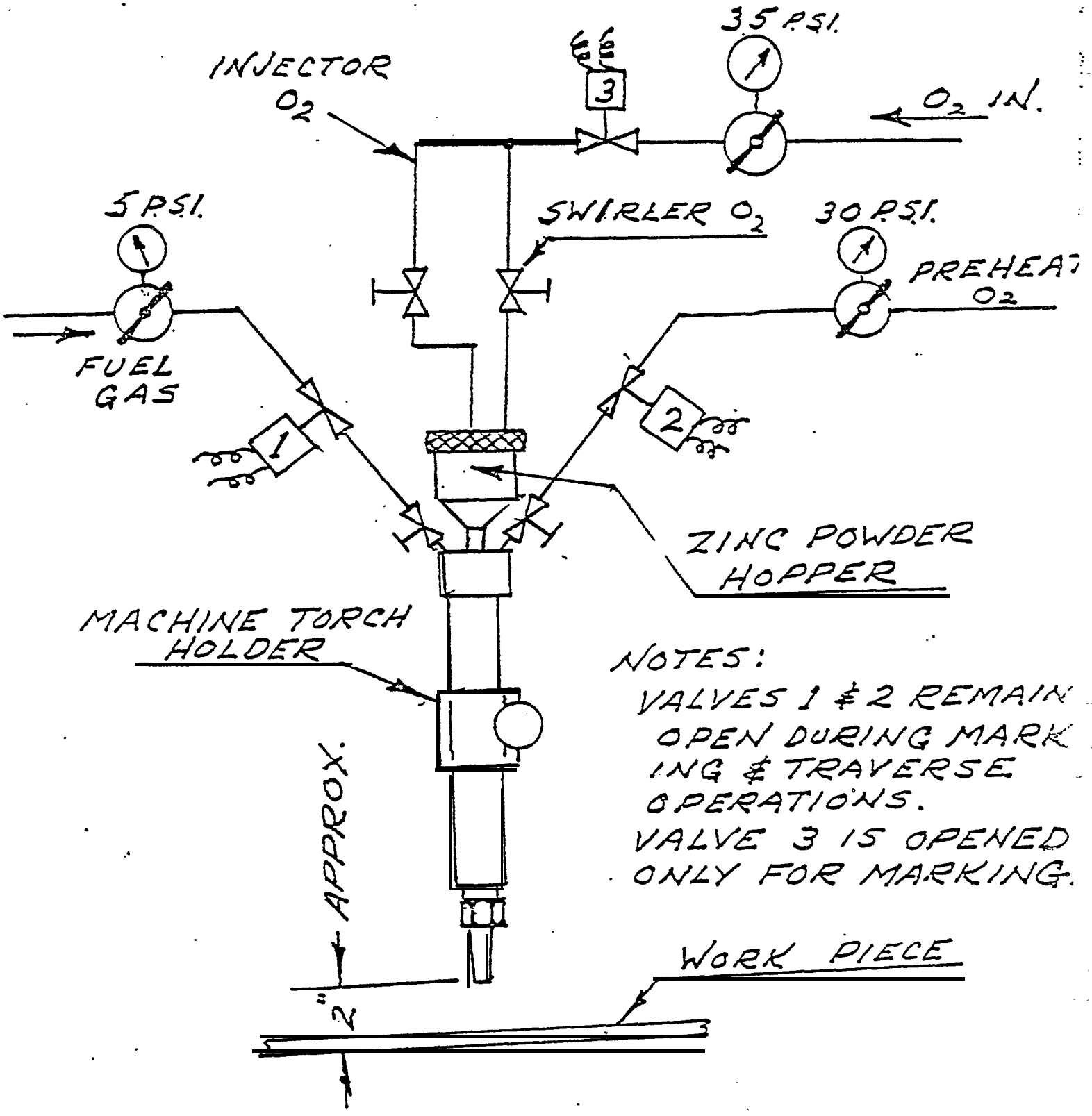
Plate Marking by Zinc Oxide Powder.

Another marking method used involves the application of a fine line of zinc oxide. This marker unit produces a small amount of fluidized zinc powder that is oxidized in a small stream of oxygen. At the exit point of the discharged fluidized stream, oxy-fuel preheat flames surround the powder stream, conditioning it and causing it to deposit a fine durable white zinc oxide line approximately one millemeter in width on the plate.

There are at least two designs of zinc powder markers in use today. One design uses automatic ignition and requires that the flame be turned on and off each time the marker is used. The other design separates the fluidized zinc oxygen stream from the preheat flames so that the preheat flames can be left lit during the marking operation. With this arrangement, the fluidized stream is turned on and off automatically as required during the operation. It has also been determined that a powder marker can operate without automatic height sensing. Experience with the marker indicates that one hopper charge of zinc oxide powder lasts several eight-hour shifts. A diagram of the latter powder marker with pressure settings is shown on Fig. 14.

Some of the advantages offered with this type of marker are:

1. It is a noiseless operation.
2. It can be used for applying sequence numbers to plate parts.
3. Low maintenance is required since it uses very few mechanical parts.



TYPICAL POWDER MARKING TORCH ARRANGEMENT FOR PROGRAMMED PLATE MARKING.

Fig. 14

Plate Coding by Paint Stick.

In all of the yards visited during this program, paint stick coding was the method used for identifying plate parts. In a few isolated cases, hammer die imprint was used on shipboard parts. On Class 1 and Class 2 parts*, the paint stick coding information is manually applied to the plate parts during the machine marking and cutting operations. With the Class 3 parts, the coding is applied either before or after the cutting operation, depending on the method used. While paint stick coding has proven to be a successful method for applying identification marks to plate parts, it does have the following disadvantages:

1. It is a time-consuming method and depending on when applied, it can cause delay in the cutting machine's production of parts. This is one of the reasons today why more small Class 3 parts are not nested With Class 1 and Class 2 parts in some shipyards.
2. Paint stick marking is always subject to error possibilities on the part of the operator Who could, by mistake, apply incorrect information.
3. It is always subject to error by the user because of hand writing misinterpretation.

Marking and Coding by Matrix Ink Jet Printers.

There are several types of Matrix Ink Jet printers on the market today. These units are programmable non-contact spray type markers with one or several heads for printing single-line or multi-line information in one pass. They are being used mainly in the packaging industry.

Through the use of a rotating head for supporting the marker, it is possible that both plate marking and coding operations could be carried out as part of the M/C program. However, some difficulties may be experienced with the small Class 3 parts where a simplification in the coding procedure is needed the most. Many of these parts would require that the Matrix letters be small in size. For example, where a part

*See page 9.

is 3" x 10" in size, the height of the letters could be no larger than 3/8th of an inch. With the larger Class 1 and Class 2 parts, the height of the letters should be 1 to 1 1/2 inches. To further meet the needs of the yard, the jet printer system should be adaptable to the smaller flame cutting machines in the system. This would require bringing the jet printers to the work pieces. Bringing the work pieces to the jet printer, in most cases, would not be practical because of the material handling problems it would impose.

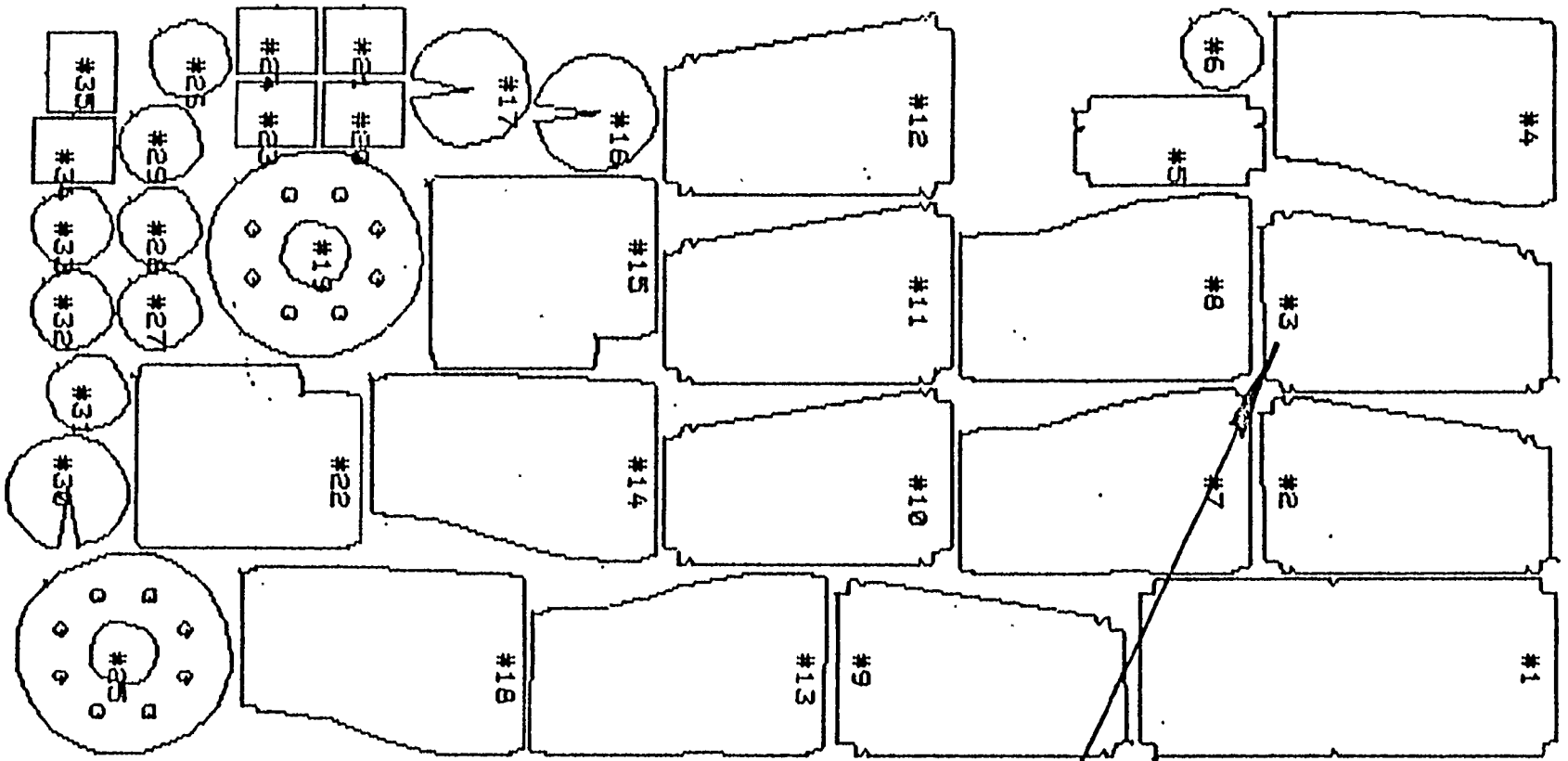
While the idea of jet printers may have some appeal, a considerable amount of development work is needed in both hardware and software for it to become economically feasible for coding and marking flame cut parts in the shipbuilding industry.

Coding by Sticker Label Application.

Today, there are available CAD-CAM sheet metal systems that provide a printout of the nested parts and gummed labels with printed coding information required on each part. Such a system is at present being used at the Avondale Shipyard in New Orleans. The parts in the nested printout and the stickers are automatically numbered in sequence so that the operator can identify each part in the nest and apply the appropriate sticker to it.

There is software available with most marine programming systems used today that allows for sequential number printout on nested programs produced by drafting machines. With little change in the machine program, this could be added to the machine's marking operation.' A typical part nest printout and the accompanying sticker printout is shown on Fig. 15.

Such a system, used in conjunction with the powder marker discussed previously would enable the flame cutting machine to write scaled numbers on the individual parts in the program.



T#40 304 — 005 — 1
Triac Industries
BltFl

g452 End 1: 8 x 0
End 2: 0.5 x 2.5
FLANGE WITH 9 HEnd 3: 5 x 0
PC. 1 of 1
0
Seam: sp

FTG's: 5
GA: 24
16 x 16

EXAMPLE OF NESTED PROGRAM PRINT OUT AND LABEL PRINT OUT— ONE LABEL PER PART.

The operator, rather than writing the code information on the plate, would apply the appropriate label to the part. Label material that weathers well is available. The advantages of such a system are:

1. It will speed up the coding process and help make it possible to include Class 3 parts in the nests of Class 1 and Class 2 parts.
2. It will minimize the error incident possibility since the coding would appear in a format that is controlled by the data processing system.

CONCLUSIONS

Through the use of modern computer oriented techniques in the preparation of ship parts cut from rolled steel plate, the following can be realized:

I. A reduction in plate costs by:

1. Introducing a computer program station with interactive and automatic program capabilities for:

   1a. Transferring Class 1 and Class 2* part programs from the main frame computer . to the program station with hard disc storage for prompt use in preparing nested programs.

   1b. The automatic part programming and combining of Class 3 parts for efficient plate utilization. This will also eliminate the need for preparation of paper templates and many of the wooden templates now used. In addition, this will eliminate template storage problems.

   1c. The preparation of nested programs of Class 1, Class 2 and Class 3 parts. See Fig. 7 for evaluation of the savings possible and Appendix 4 for BASIC FEATURES REQUIRED IN A PART NESTING SYSTEM FOR THE SHIPBUILDER.

2. Equipping secondary shape cutting machines with numerical controls in place of optical template following devices and tying the machines into a DNC network as shown on Fig. 8. By so doing:

   2a. The operations of the secondary machines can be integrated with that of the primary machines and an improvement in efficiency realized. See Figs. 7 and 9.

   2b. The number of special sized plates required can be reduced thus leading to a reduction in material and handling costs. See Figs. 2 and 9.

* See section on CLASSIFICATION OF PARTS CUT FROM STEEL PLATE. **(page 9.)**

II. A reduction in the time and labor costs by:

1. Using the plasma cutting process in place of the oxy-flame cutting process for contour cutting of rolled plate less than one inch in thickness. This will result in an increase in cutting speed and elimination of thermal distortion effects realized with the oxy-flame cutting process. See Fig. 6.

2. Equipping the secondary machines with one plasma torch each. This will result in:

   2a. Better utilization of material since the positioning of one torch over the operating field can be more selective than can four oxy-flame cutting torches traveling at 1/4 the speed.

   2b. A program match between the primary machines and the secondary machines, allowing them to operate from the same program or extension thereof. See Figs. 8 and 9.

   2c. A reduction in labor costs. See Fig. 7.

3. Using the powder marking process (see Fig. 14) in place of the center punch marking process thus:

   3a. Eliminating noise.

   3b. Reducing maintenance costs.

   3c. Allowing for an increase in marking speed.

   3d. Permitting the use of sequence number identification of the parts.

4. The use of computer printed labels for part identification, thus eliminating the need to paint stick code individual parts. See Figs. 5 and 15.

SHIPYARDS VISITED DURING THIS STUDY.

Avondale Shipyards, Inc., New Orleans, La.
Bath Iron Works, Bath, Me.
Bay Shipbuilding Corp., Sturgeon Bay, Wi.
Ingalls Shipbuilding Div., Pascagoula, Ms.
Marinette Marine Corp., Marinette, Wi.
National Steel Shipbuilding and Drydock Co., San Diego, Ca.
Newport News Shipbuilding and Drydock Co., Newport News, Va.
Peterson Builders, Inc., Sturgeon Bay, Wi.
Todd Shipyard, Inc., San Pedro, Ca.

SHIPBUILDING ORIENTED SOFTWARE COMPANIES VISITED DURING THIS STUDY.

Cali Associates, Inc., Metairie, La.
Computervision, Inc., Bedford, Ma.
Cutting Technology, Inc., Lexington, Ma.
Cybermation, Inc., Cambridge, Ma.
Shipping Research Services, Inc., Houston, Tx.

COMPANIES VISITED THAT OFFER NESTING SYSTEMS.

Cali Associates, Inc., Metairie, La.
Camsco, Richardson, Tx.
Computervision, Inc., Bedford, Ma.
Cybermation, Inc., Cambridge, Ma.
Shipping Research Services, Inc., Houston, Tx.
*Union Carbide Corp., Linde Div., Tonawanda, NY

*Visited Linde Division's part nesting exhibit at the Dallas AWS National Convention.

REFERENCES

1. Cascastini, A., et al. "A Computer-Aided Design System For Pattern Grading and Marking in the Garment Industry." CAD 76 Proceedings.

2. Albano, Antonio. "A Method to Improve Two-Dimensional Layout." Universita di Pisa, Istituto di Scienze dell' Informazione, Corso Italia 40, 56100 Pisa-Italy.

3. Bengt-Erik Bengtsson. "Packing Rectangular Pieces--A Heuristic Approach." The Computer Journal, Vol. 25, No. 3, 1982. Inst. of Technology, Dept. of Computer Science, Box 725, S-220-07 Lund, Sweden.

4. Chazelle, Bernard. "The Bottom-Left Bin-Packing Heuristic: An Efficient Implementation." IEEE Transactions on Computers, Vol. C-32, No. 8, Aug. 1983.

5. Oian, Jorn, et al. "An Interactive Computer Graphics Approach to the Problem of Nesting, of Plane Parts on a Raw Steel Format." CAD 76 Proceedings.

6. Albano, Antonio, et al. "Nesting Two-Dimensional Shapes in Rectangular Modules." CAD 8 (No. 1) 27-33 (Jan. 1976).

7. Albano, Antonio, et al. "A Heuristic Solution of the Rectangular Cutting Stock Problem." The Computer Journal, Vol. 23, No. 4, 338-343, Nov. 1980.

APPENDIX 1

THE ADVANTAGES AND DISADVANTAGES REALIZED WITH THE OXY-FLAME CUTTING PROCESS.

The advantages are:

1. It is effective over a wide range of material thicknesses. Effective range with most standard machine cutting torches is from approximately 1/4 inch thick material to over 12 inches thick with good quality of cut surface. The maximum thickness cut that is known to the writer is 87 inches.
2. When cutting narrow parts, a multi-torch arrangement can be used with cutting machines, thus increasing the productivity of the operation.
3. It can very effectively be used to prepare the various bevels required in the preparation of plate edges for welding.
4. There is no other known process that can compete with the oxy-flame process in effectively cutting contoured sections from heavy steel plate.
5. The initial cost of an oxy-flame cutting torch system is considerably less costly than the cost of a plasma cutting system.

The disadvantages are:

1. In the 1/4 inch through the 1 inch material thicknesses, the cutting speeds are considerably less than that possible with the plasma cutting process.' See. Fig. 6.
2. Preheat is required for starting and maintaining the cutting process. This could take between 20 seconds and one minute depending on the intensity of the

preheat flame. Depending on the number of pierce starts required, this slows down the cutting process.

3. The process heat input to the work piece can cause distortion of the finished product. In the interest of minimizing distortion of the cut parts, certain precautions must be taken in programming the cutting sequence and the direction of the cutting torch travel. In addition, care must be taken by the operator in setting the speed, the direction of the cutting torch travel, the cutting sequence, the fuel gas and oxygen pressures and the preheat high and low levels.

4. The nesting of small Class 3 parts with Class 1 and Class 2 ship parts is often impractical because of the time and the heat distortion involved,

5. The oxy-flame process cannot be used to cut non-ferrous materials. In addition, the process cannot be used to cut stainless steel unless some energy producing additive such as iron powder is added to the cutting oxygen stream.

APPENDIX 2

THE ADVANTAGES AND DISADVANTAGES REALIZED WITH THE PLASMA CUTTING PROCESS.

The advantages are:

1. The cutting process is fast and is several times that realized with the oxy-flame process. See Fig. 6.
2. No preheat is required for starting the cutting process. The piercing start is almost instantaneous. This not only saves time, but it also minimizes the heat input to the work piece. With plasma cutting, the heat affected zone is minimal.
3. Distortion of the plate due to heat input is practically eliminated. With the plasma cutting process, the plate can be completely immersed in water during the piercing and cutting operations.
4. The use of tabs for joining the cut parts to the main plate is not always necessary for eliminating part movement on the cutting bed.
5. Individual discreet parts can be cut one at a time which simplifies part programming and the nesting of small parts.
6. Both ferrous and non-ferrous metals can be successfully cut with the process.
7. Use of the process can be instrumental in causing a higher plate yield, by making possible the nesting of small Class 3 parts with Class 1 and Class 2 parts without upsetting the manufacturing process time balance.'

The disadvantages are:

1. The power requirements are high. To effectively cut ship parts at the speed ranges shown on Fig. 6, 80 to 100 KW per torch is required.

2. Noise and arc glare could be a problem if steps are not taken to minimize or eliminate them. Most plasma cutting operations in the United States are carried out over a water table where the bottom of the plate either touches the water or is slightly above it. In these operation, a water muffler is used to reduce the noise level. The water muffler also helps reduce the arc glare and work piece temperature. In some installations, the plate being. cut is completely immersed in water and the cutting is done approximately one to two inches below the surface of the water. The arc glare is greatly- reduced and the noise is almost eliminated in these operations. Those using the underwater method claim that the parts produced are more accurate, particularly where the parts being cut are rather long and slender in shape.

3. The effective thickness range of cutting steel plate is up to one inch. Thicker material can be cut., but at a sacrifice in speed, cut surface quality and accuracy.

4 The plasma cutting process is directional. The standard swirl ring used in the torch for handling plasma gas, requires clickwise travel around the work piece. With this process, there is a tendency for the kerf of the cut to have tapered sides. By using the swirl ring in the torch, the taper shifts so that one side

is almost vertical, leaving the scrap side of the kerf tapered. When mirror image cutting is done, one torch must travel in a counter clockwise direction. In this case, a left-handed swirler must be used in the mirror imaged torch.

5. A study conducted by one user indicates that while there is considerable cost advantage to the user when using the process for cutting ship plate, there is a slight increase in the cost of consumables per foot of cut length over that realized with the oxy-flame cutting process.

APPENDIX 3

SOME ADVANTAGES AND DISADVANTAGES REALIZED WHEN USING SPECIAL SIZED PLATE IN SHIP HULL CONSTRUCTION.

Some advantages are:

1. In the pre-nest assembly of parts on the plate, the operating field area can be adjusted to best suit the collection of both large and small parts being nested and hence a more efficient nesting arrangement of parts can often be realized.
2. Segment sizes that best suit the hull construction can be used and the footage of welded joints required reduced.

Some disadvantages are:

1. It causes a delay in order placement in some cases because more detailed engineering design is required in determining the plate sizes to order.
2. It causes an increase in the number of plate sizes required and, therefore, a larger plate storage facility is required to permit the efficient use of grid location assignment.
3. The loss of a plate due to spoilage or mislocation can prove costly because of the additional expense and delay caused by replacing the plate with a similar size or other size considered suitable.
4. The size premium charged. by the steel mill plus the hidden increase in plate yard handling expenses could amount to an overall 4% or higher increase in material costs before the plate reaches the burning tables.
5. It causes a cost increase in the production department's scheduling and plate assignment detailing operations. This cost is usually hard to define.

APPENDIX 4

BASIC FEATURES REQUIRED IN A PART NESTING SYSTEM FOR THE SHIPBUILDER.

1. The system to be supplied with a computer work station including:
   a. A keyboard.
   b. A 15" or larger CRT screen.
   c. Graphic capabilities with a light pen or other means for identifying and moving parts.
   d. A program storage system with a minimum capacity of 10 megabytes.
   e. A label printer and a device for producing a hard copy of a part or nested program.
2. Local entry and storage of existing part programs written in the format and code used by the machines in the yard or entry and program storage through communication with the main frame computer.
3. Means for:
   a. Restoring the system information in case of a major systems failure.
   b. Transmitting parts or nested programs directly to the cutting machines in the DNC system.
   c. Local means for entering enhancements and modifications to the system.
4. Local generation and storage of part programs from dimensioned engineering drawings.
5. Common part program generation through entry of critical dimensions.
6. Scaled display of parts to be nested, with a display of the quantities required of each.
7. Local capability to nest selected parts on assigned plate areas by interactive graphic method.
   a. The automatic nesting of parts selected in assigned areas of the plate work piece.

9. Ability to combine part programs as desired into a defined grouping and the ability to move the grouping as a unit during a nesting procedure.

10. Automatic inventory countdown during the nesting procedure.

11. Movement of any part to any screen location by cursor. or keyboard control.

12. Continuous 360° part rotation.

13. Ability to add or delete parts from the nest and automatically adjust inventory quantities accordingly by keyboard or cursor control.

14. Operator selection of part lead-in location at time of the nest preparation.

15. Operator selection of marking/cutting sequence at time of nest preparation.

16. Rapid traverse moves to be displayed and identifiable on-the nest printout.

17. Ability to join parts at the nesting stage.

18. Automatic-part tabbing by 'cursor or keyboard control.

19. Sequence numbers to appear on the nested part program printout.

20. Optional sequence numbers with scale selection to be part of the cutting machine's marking program.

21. Ability to provide optional check dimensions on the nested program printout.

22. Ability to mirror image any part and nest it.

23. Choice of travel direction.

24. Reaction time to any keyboard or cursor input command not to exceed 10 seconds.

25. Automatic control for designated minimum spacing of adjoining parts.

26. Enlarged zoom-in control for examining part intersection areas.

27. Capability of being tied into cutting machine controls through a DNC (Direct Numerical Control) system allowing for part or nested program call-up from the cutting machine's console or operating panel.

28. Automatic printout of part identifications, nest efficiency, the length of the torch's cutting path and the time required to cut and mark the nested program.

29. Ability to produce printed labels with part matching sequence numbers and the part coding information required on each part.

PANEL SP-2

OUTFITTING & PRODUCTION AIDS

Louis D. Chirillo
L.D. Chirillo Associates

Chairman

A Presentation to the
National Shipbuilding Research Program Symposium
11-13 September 1985 - Long Beach, California

by Louis D. Chirillo* for SNAME Panel SP-2

Despite there not having been any formal presentation of Panel SP-2 research since the September 1983 IREAPS Technical Symposium, much information has been disseminated. Since then, the following additional National. Shipbuilding Research Program (NSRP) publications were widely distributed:

- o Design for Zone Outfitting
- o Design Modeling
- o Pre-Contract Negotiation of Technical Matters
- o Product Oriented Material Management

Because of demand, "Process Analysis Via Accuracy Control", originally issued in February 1982, has been revised and is about to be reissued.

Various papers and comments which further promote SP-2 research were presented in Hampton Roads, Seattle, Los Angeles, San Antonio, New York, Norfolk and Washington, D.C. In addition, responses were made to two extraordinary opportunities. One was 20 June 1984 testimony to the House Merchant Marine Subcommittee, published in the February 1985 issue of the SNAME Journal of Ship Production. The second involved participation in a work group for the Marine Board, National Research Council, which resulted in the report 'Toward More Productive Naval Shipbuilding',. distributed about March 1985. Of all, the latter is the most significant because U.S. shipyard managers becoming as effective as the world leaders in Japan, is now very dependent upon how the Navy administers programs for building, converting and overhauling ships.

'Toward More Productive Naval Shipbuilding" is replete with references to SP-2 end products, descriptions of their acceptance by shipbuilders even for building naval ships, and recommendations for their acceptance by the Navy. Specifically the report advises 'To foster the use of zone oriented ship construction, the Navy should: (1) develop means to apply the technology in preliminary and contract design, (2) educate its personnel in the advances being embraced by shipbuilders so that Navy practices and procedures can be adapted in support of them, and (3) work together with its shipbuilders to provide a receptive environment for the use of productivity improving technology." The report also addresses the benefits of a Product Oriented Work Breakdown Structure (PWBS) and relates statistical control of accuracy variations in process, to abilities to withstand high-impact shock and great submergence depths. Both are military requirements.

Except for the application of zone logic for ship alteration and repair by Puget Sound Naval Shipyard and the inclusion of pertinent courses in the curriculum at the Engineering Duty Officer School (both started before the report was issued), at this time there are no known Navy responses to the Marine Board's recommendations concerning Panel SP-2 end products.

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* L.D. Chirillo Associates of Bellevue, Washington, assists the Los Angeles Division of Todd Pacific Shipyards Corporation in management of part of the Maritime Administration created government/industry National Shipbuilding Research Program.

A NEW SHIPBUILDING MEASUREMENT TOOL
PHOTOGRAMMETRY FOR MEASURING CIRCULARITY OF SUBMARINE HULLS

BY

L. R. JACOBSEN
P. N. BIONDO

ABSTRACT

Photogrammetry is the art, science, and technology used in the interpretation of coordinate data about physical objects by the measurement and analysis of photographic images. The Electric Boat Division of General Dynamics utilizes photogrammetry primarily, in measuring the as-built circularity (out-of-roundness) of the TRIDENT Class pressure hull cylinders. Various other mechanical methods had been used in the past for measuring hull circularities; but the unique features and capabilities of photogrammetry proved itself well to meet demanding shipyard needs. The large awkward shape of submarine pressure hull cylinders, in combination with the flexibility and ease of the photogrammetric technique, makes photogrammetry a productive tool for Electric Boat's shipbuilding applications.

INTRODUCTION

Electric Boat Division first employed the use of photogrammetry for the purpose of measuring the circularity of the SSBN726 TRIDENT Missile Compartment. The major problem in measurement of this compartment were the circularity measurements to be taken in the area of the missile tubes (large masses of welded in structure) which protrude from the hull. This condition made it very difficult for conventional methods to be implemented. In current submarine construction, it is required that circularity measurements be taken at frame and mid-bay locations at regular intervals along the length of the pressure hull. Photogrammetry provided an accurate means that could be used in way of this missile tube structure.

The United States Navy, Electric Boat's primary Customer, requires by specification that all TRIDENT sub marines meet a Navy specified tolerance for any point deviating from a measured circle encompassing the circumference of -the pressure hull cylinder. Navy specifications also detail a variety of mechanical methods that can be used in taking hull circularities.(l) These methods include: the bridge gauge method, internal swing arm, internal radii, method of optical squares, and the external template method. The internal radii method is employed at our Hull Cylinder Manufacturing Facility at Quonset Point, Rhode Island. Internal Circularities can be taken at internal measurement stations within a hull cylinder, this must be performed after all major welding has been accomplished in this area. This method of taking circularities has proven reliable and accounts for approximately 37% of the total measured hull circularities taken on a TRIDENT submarine. External hull circularities again have to be taken after major welded in structure has been installed such as the missile tubes, decks, foundations, tanks and after cylinder hull butts

have been welded. Thus, external circularities are primarily taken at Electric Boat's Groton, CT facility where final fit-up and assembly of the TRIDENT pressure hull cylinders takes place. Electric Boat, in the past, had used an external wooden template in taking these external circularities. The method of taking external hull circularities by means of an external template lends itself well when taking circularities over a round cylinder less than 30 feet in diameter, but the condition of taking a hull circularity in way of a protruding missile tube all but eliminated the use 'of the external template method from consideration. Recently, the use of the external wooden template has been replaced by photogrammetry in taking all external circularity measurements on the TRIDENT pressure hull cylinders.

PHOTOGRAMMETRIC MEASUREMENT

A brief on this measurement "tool" follows and it is presented as a consolidation of descriptive information extracted from several sources in the photogrammetry profession.

"Broadly described,. photogrammetry is an indirect measurement process. It is the process of extracting meaningful two or three dimensional measurements of a scene from one or more photographs of the scene. The derived information may be in the form of coordinates of points, distances, outlines of features or shapes of surfaces. Following a photographic phase, which is usually performed on the Customer's site, the exposed film which is in the form of highly ground flat glass plates are brought back to the vendors office for analysis. Measurement of discrete points on the image are made directly off the negative plate by the use of analytical comparator. The comparator digitizes each point on the image to a X, Y photogrammetric coordinate grid system.

Subsequent numerical triangulation produces a digital model of the scene which in turn is processed to yield numerical and/or graphical results. The numerical information so derived may be in the form of coordinates of points, distances, outlines of features or shapes of surfaces. Measurement accuracies are well established, for example, the method using fully analytical photogrammetry yields tolerances upwards of ± 1 part in 60,000 of the major dimension of the scene photographed.

The desired dimensional data of the scene photographed can be obtained through several combinations of photogrammetric processes. The various possibilities are diagrammed in Figure 1. For most shipbuilding measurement applications, fully analytical photogrammetry is preferred, since it offers point data of higher accuracy than either the analog or semi-analytical methods.

The unique capability of photogrammetry is considered a complement to, not a substitute for, conventional measurement methods.

Some advantages of measuring with photogrammetry are when:

1) Complexity of shape or detail of the scene is restrictive.

2) Relative directions. to all points of interest within the field of view of a camera are recorded instantaneously.

3) All data can be obtained in a short period, minimizing the effect of thermal and gravity induced changes.

4) Due to the short period of time to take photographs, there is a minimum interference with ongoing work. In some instances, work can proceed without interruption.

5) Orientation of attitude of the scene is of no consequence as long as there is room to stand off with the camera.

6) Photographs may be taken and achieved for any. potential need to produce data at a future point in time.

There are some disadvantages to the photogrammetric measurement method, notable;

1) Results of photogrammetric measurements are not produced instantaneously.

2) Useful photographs cannot be taken in heavy rain, snow, or fog.

3) Measurements in very confined spaces are generally not practical due to the large number of photographs which must be used to cover the entire scene." ---

IMPLEMENTATION OF THE METHOD AT ELECTRIC BOAT DIVISION

The potential of photogrammetry for submarine hull circularity measurement was apparent after assessment of the work of investigators who prepared the report "Photogrammetry in Shipbuilding" under MARAD sponsorship(2). As early as March, 1977, this method's apparent usefulness for hull contour measurement was identified in an in-house new construction technology brief.

Conversations were then initiated with a vendor of photogrammetric services, J. F. Kenefeick, to investigate measurement of a hypothetical, long, large diameter cylinder, accessibly only from the outside. After developing tentative photographic scheme, Kenefick performed a computer simulation of the problem and determined that photogrammetry was a viable solution to the measurement task and that data could be produced within the tolerance of f ± 0.05 inch.

We have noted that photogrammetry was not an approved method for circularity measurement, however, receptivity of this new method by SUPSHIP, Groton, NAVSEA PMS396, and Shipyard Operations allowed planning and subsequent implementation to proceed with their full cooperation. (3)

PHOTOGRAMMETRIC MEASUREMENT OF MISSILE COMPARTMENT HULL CIRCULARITY - SSBN726

The shipyard site and the "object" to be measured is best described by referring to Figures 2 through 5. Figure 2 is an overview of the TRIDENT Missile Compartment within the assembly building. Figure 3 shows the typical ship support system (strongback and poppets) and is an obstacle to line of sight to some points of interest. Figure 4 shows missile tube projections which make the simple cylinder an irregular object. Figure 5 is representative of points of interest (target and station layout) on the hull cylinder.

Planning

A photogrammetric plan for the TRIDENT hull survey was developed which considered placement of the photogrammatist and the camera's available working space, field of view of the camera, depth of focus and the level of accuracy desired.

Two data processing phases are employed: 1) photogrammetric triangulation to obtain the dimensional coordinates for all the targets, and 2) manipulation of these coordinates to translate and rotate coordinates into a meaningful system and calculation of a circle best fitting a series of points.

The target coordinate measurements are processed through vendor-developed software computer package3 to accomplish the mathematical solution of an analytic multiray photogrammetric triangulation.

Data manipulation consists of calculation of the plane which best fits all targets on the measurement station and calculation of the circle in that plane which best fits the same targets.

The quality of the solution is assessed by checks of measurement residuals, standard deviations of target coordinates, and fit to scale reference distances.

Results from data processing are tabular listings of point departures from the least squares solution mean radius at the 10° increments, this is shown graphically for a frame in Figure 12.

The point departures and mean radius input directly to the Electric Boat Division computer program which iterates the data and assesses whether the maximum acceptable deviation has been exceeded. Figure 13 is typical of the output form which Electric Boat uses to document each measured circularity station.

1_A target's image must be on two or more photographs in order for it to be triangulated.

2_j. F. Kenefick currently uses the WILD AC-1 Analytical Comparator. Direct reading to .001mm, with the two Axis Digitizer can be achieved. Figure 11.

3"Close range analytical bundle solution".

SOME GENERAL COMMENTS RELATIVE TO THE METHOD USED

1) The initial photography effort required seventy-seven(77) photos on the SSBN726, forty-four (44) of which were for the forward-most fifteen (15) measurement stations. These were taken on a Saturday, the balance, thirty-three (33) were of the after ten (10) stations and were taken on Sunday. The entire photographic process; including shipyard supporting activities, was completed in a weekend.

2) Experience gained on SSBN726 and subsequently on SSBN727 enabled the photogrammist to revise the SSBN728 photo plan to fourteen (14) photo frames per station, thereby increasing the total photos to ninety-eight (98). In addition, the 5^0 targets were deleted to remove the bias resulting from an excess target population on the ships sides, which was in evidence in the SSBN726 survey results.

3) On SSBN728, less time was taken to perform the photography allowing time for overall "tie-in" photos of the missile compartment to be taken. It is now possible to 'relate station circles and the point departures therefrom to the ship's coordinates. In turn, this enables photogrammetric triangulation of all data points on the hull. These results can, at some future date, provide offsets from which to construct an as-built body plan of the missile compartment section of the hull.

4) Measurement of the negatives and data processing performed on a routine basis has taken an average of twelve (12) weeks, thus it is evident that results of photogrammetric measurements are not produced instantaneously.

OTHER USES

1) Electric Boat Division has utilized photogrammetry in recent months in some different applications. One application is the measurement of the flatness of the interfacing surface between the Bow Dome to the non-pressure hull frame, see Figure 14. Construction tolerances require a specified flatness be maintained over the depth and circumference of this interface. Due to a variety of hull considerations, particular attention has been given to this problem in determining and maintaining the flatness over the area.

In the construction of the early SSBN's Electric Boat Division hired an outside subcontractor to machine this interface to meet the proper flatness requirements. In the construction of the more recent SSBN's, Electric Boat Division has assumed the role of trying to maintain this

flatness requirement, but with limited success. Electric Boat Division made the decision to bring in an outside vendor to determine the flatness at this frame surface.

GEOD Corp. of Oak Ridge, New Jersey was given the task of providing raw coordinate data about this frame interface by the use of photogrammetry. Measurement stations were layed out at 180 locations around the circumference at every 2^{0}. In addition, at each circumference station, targets were marked at 4 equally spaced locations along, the depth of the frame, totaling 720 locations to be measured. GEOD used the technique of comparing overlapping photos in a stereo pair solution. In this way, the flatness of the frame interface could be better determined.

The end product of this effort, was the determination of the maximum high and low point deviations measured through a best fit plane of the frame interface. with the raw coordinate data received from the vendor, engineering personnel inputted this data into Electric Boat Division's CAD system so as to develop a contour map detailing the high and low points of the frame interface, Figure 15. The shipyard then utilized this information to determine what areas of the frame interface they should-machine to bring the frame within drawing tolerance.

2) Electric Boat has used photogrammetry to measure the hull contours of one of the 688 Class Submarines. The purpose was to develop the profile of the exterior surface of the hull, so a precise mounting of special hull equipment could be accomplished. The tolerances for installation of this equipment are required to be very exact.

Photogrammetry was one of the few methods known that could provide this type of information with the accuracy required and within the time allotted during the ship availability.

3) In addition to the uses described earlier, potential applications for photogrammetric measurement under evaluation at Electric Boat Division. These include:

- Hull plate mapping for backfit installations
- Pipe targeting - as a replacement for wire templates
- Sphericity of hemihead end closures
- Graving dock cell movements with time or events
- Propeller/blade measurement - to obtain accurate as-built dimensions for comparison of one propeller to another

4) Other shipyards have employed this new shipyard tool for measurement of large irregular shaped ship elements. As an indication of the expanding use in shipbuilding activities, briefs of some specific recent photogrammetric surveys and their attained tolerances are reported as follows:

- o A three dimensional survey of the bottom section of the 1,035 feet tall COGNAC drilling platform jacket structure. The section is 175 feet high and measures 342' x 325' at the bottom and 311' x 283' at the top. Locations and elevations were determined to 0.12 inch tolerance - Shell Oil Co.(4)

- o Determine three dimensional geometry of a 24 ton FFG strut casting as a QC measure. Tolerance achieved ± .03 inch - Todd Pacific Shipbuilding.

- o Check the alignment of the center of the "Palar Star" rudder palm and the *axis* of the gudgeon and parallelism between palm and counterbore of the gudgeon. To1erance achieved ± .02 inch over all surfaces of the 15' x 17' rudder - U. S. Coast Guard.

- o Produce three dimensional coordinates of approximately 450 points distributed over the surface of a DD963 Sonar Dome Rubber Window (Lg 38', Breadth 20, H5 8'). Tolerance of coordinates was Y 0.03 inch - Ingalls Shipbuilding.

- o Surveying mating surfaces of as-built halves of a 126,000 DWT Tanker.(5)

- o Checking as-built dimensions of body. plans for new Navy Cl ass Frigates.

IMPLEMENTING IN-HOUSE CAPABILITY

Electric Boat Division has considered the option to acquire in-house capabilities to perform its own photogrammetric measurements in the shipyard. Several aircraft companies and at least one other shipyard have acquired this capability. Photogrammetry should only be established in-house when the number occasions, wherein this special measurement method technically warrants the capital investment and training entailed. One could project that a team with in-house capability at one Corporate Division having the primary work load, could serve other Divisions on a call basis and offer contact services on a not-to-interfere basis.

In adopting photogrammetry as a measurement tool the Shipbuilder can select from three alternatives.

- o Develop total in-house capability
- o Retain a photogrammetrist by subcontract
- o Use an in-house/subcontract combination

A photogrammetric unit to be totally self sufficient requires hardware, software and training of the team.

Initially, a dedicated two man team, a person experienced in photogrammetry and a shipyard technical person, would be required. If in-house computer support is available, approximately a three month start-up period should be allowed.

CONCLUSIONS

Photogrammetry is a relatively new, proven, measurement tool for shipyards. Although it is not a real time measurement system, it does offer minimum disruption to production, immediate implementation, and greater accuracy than other methods for measurement of objects of irregular shape complicated by size or object accessibility.

Whether the modest investment to obtain in-house capability, or contracting for services, best suits a shipyard depends simply on the number of special measurement surveys found necessary in the performance of work under contract.

The method complements the shipyard measurement tool inventory, it does not displace other conventional and convenient measurement tools.

REFERENCES

(1) NAVSEA 0900-LP-006-9010 "Fabrication, Welding and Inspection of HY 80/100 Submarine Hulls"

(2) Photogrammetry in Shipbuilding - July 1976

National Shipbuilding Research Program
U. S. Department of Commerce,
Maritime Administration - PB-262-130/45

(3) Circularity Measurements of Submarine Hulls by Photogrammetry - Final Report - November 1978

(4) Photogrammetric Surveys of Cognac - J. F. Kenefick

1979 Offshore Technology Conference,
Houston, Texas

(5) Predicting the Fit of Ship Built in Halves - J. F. Kenefick and D. D. Peel,

1978 International Society of Photogrammetry Symposium - Stockholm, Sweden

Prepared for General dynamics/Electric Boat Division by J. F. Kenefick

LIST OF FIGURES

FIGURE	DESCRIPTION
1	PHOTOGRAMMETRIC SOLUTION
2	TYPICAL TRIDENT SUBMARINE MISSILE COMPARTMENT
3	STRONGBACK ARRANGEMENT SUPPORTING THE TRIDENT HULL
4	BLOWUP OF MISSILE TUBE PROJECTIONS
5	MEASUREMENT STATION LAYOUT, SHOWING SIDE OF TRIDENT HULL
6	PHOTOGRAPHIC PLAN FOR THE TRIDENT HULL TYPICAL TRANSVERSE SECTION
7	LONGITUDINAL SECTION SHOWING LONGITUDINAL SPACING OF PHOTOGRAPHS
8	BLOWUP SHOWING PHOTOGRAMMETRIC TARGET AFFIXED TO THE TRIDENT HULL
9	WILD P31 TERRESTRIAL CAMERA LEFT: MOUNTED ON SURVEYING TRIPOD ABOVE: MODIFIED FOR HAND-HELD USE
10	TYPICAL GLASS PLATE NEGATIVE, SHOWING MEASUREMENT LAYOUT AND TARGETS
11	WILD HEERBURG AC-1 ANALYTICAL COMPARATOR WITH ASSOCIATED COMPUTER SYSTEM
12	EXAGGERATED CIRCULARITY CONTOUR
13	TYPICAL EBDIV CIRCULARITY FORM DOCUMENTATION
14	BOW DOME INTERFACE ATTACHMENT
15	CONTOUR PROFILE OF NON-PRESSURE HULL INTERFACE

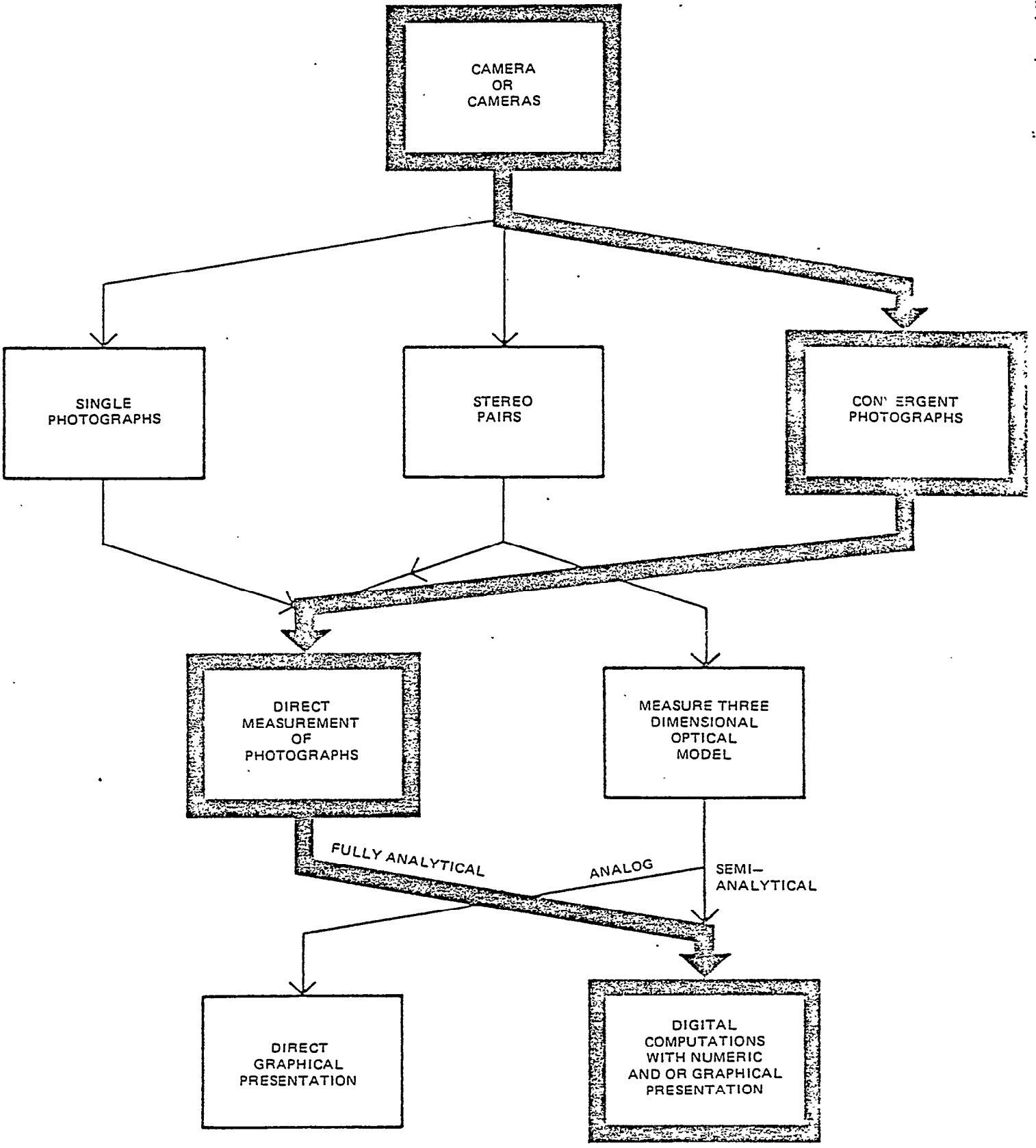


Figure 1 - Photogrammetric Solution Processes

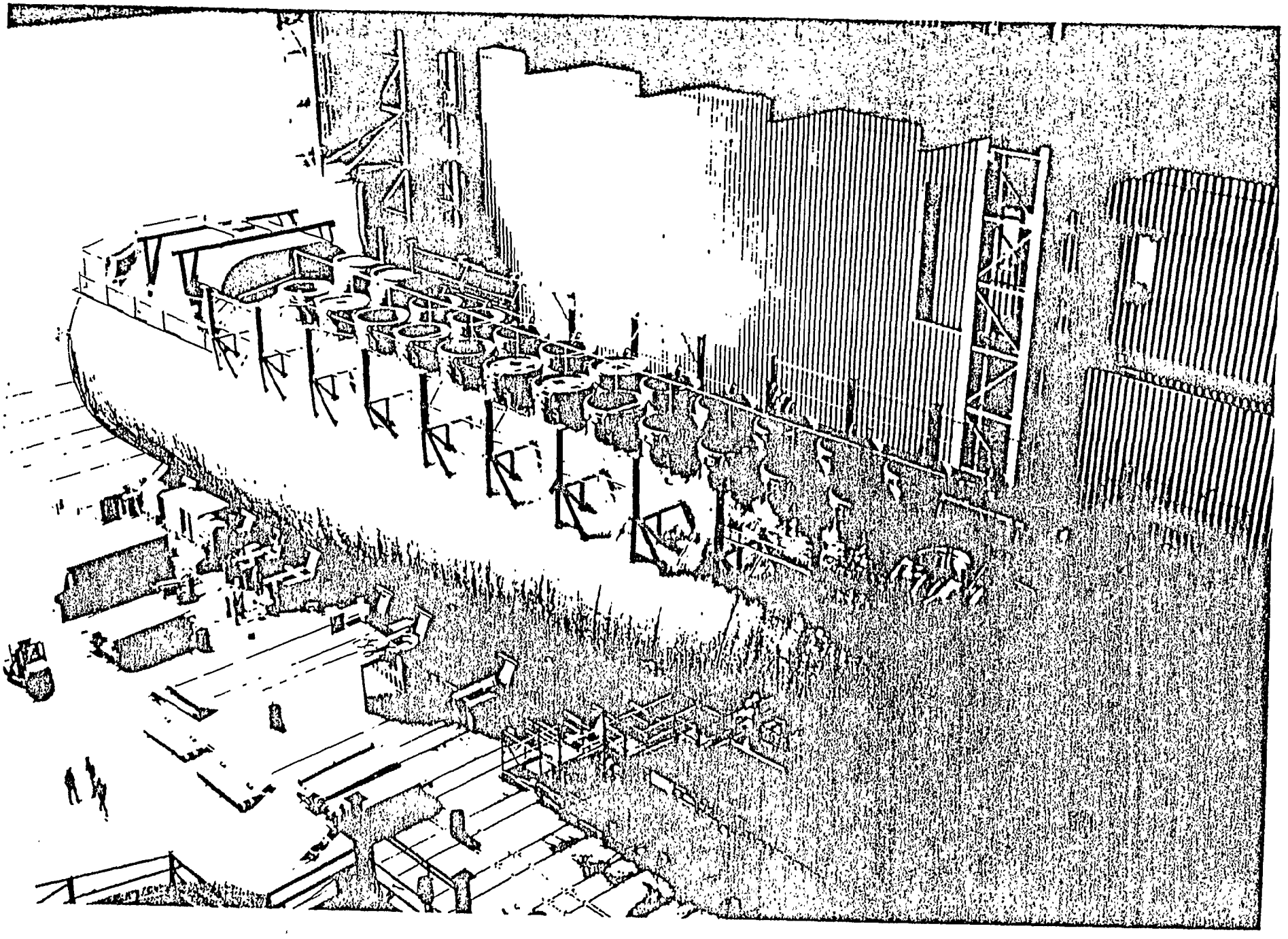


Figure 2 Typical TRIDENT Submarine Missile Compartment

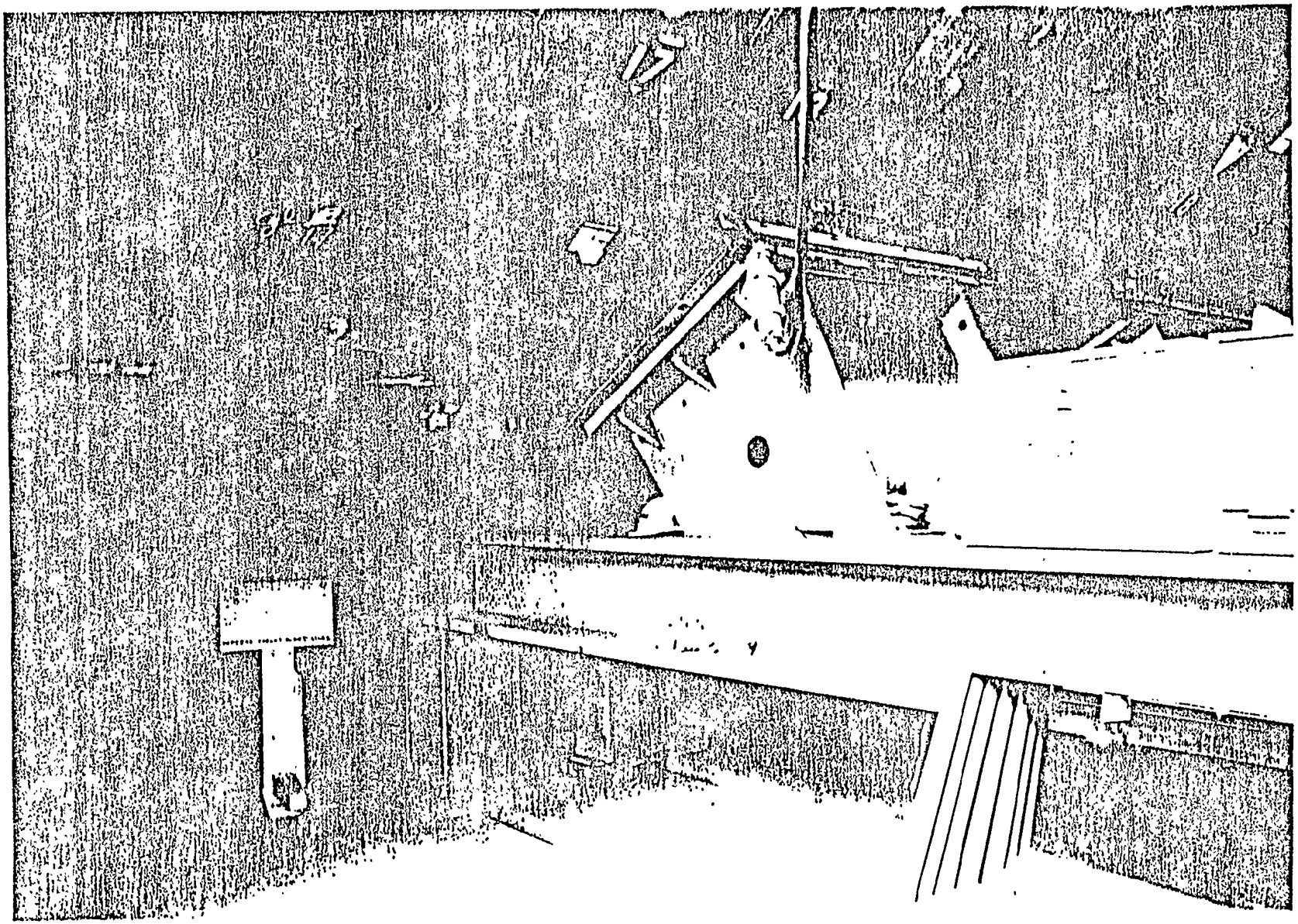


Figure 3 Strongback Arrangement Supporting
The TRIDENT Hull

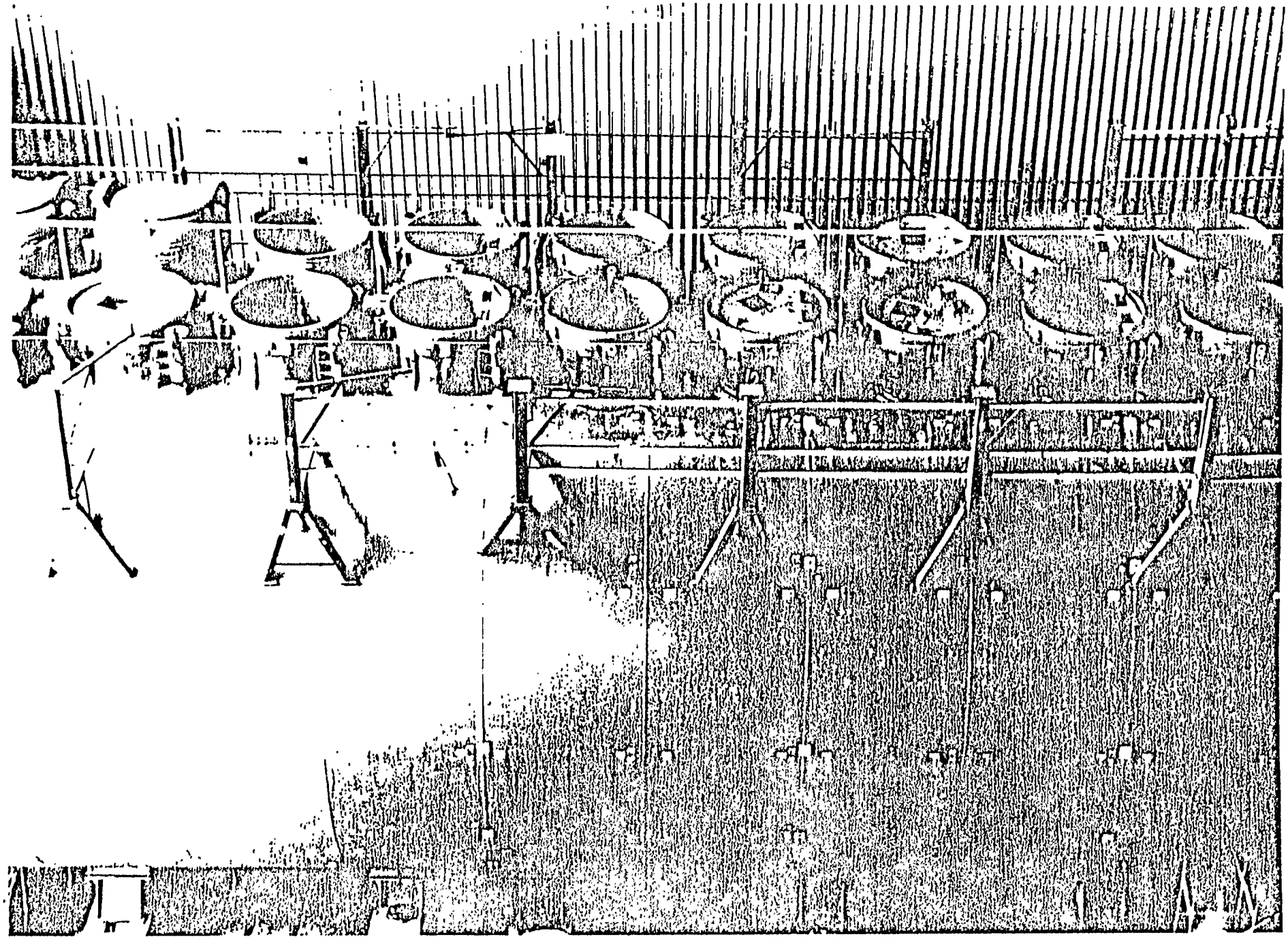


Figure 4 Blowup of Missile Tube Projections

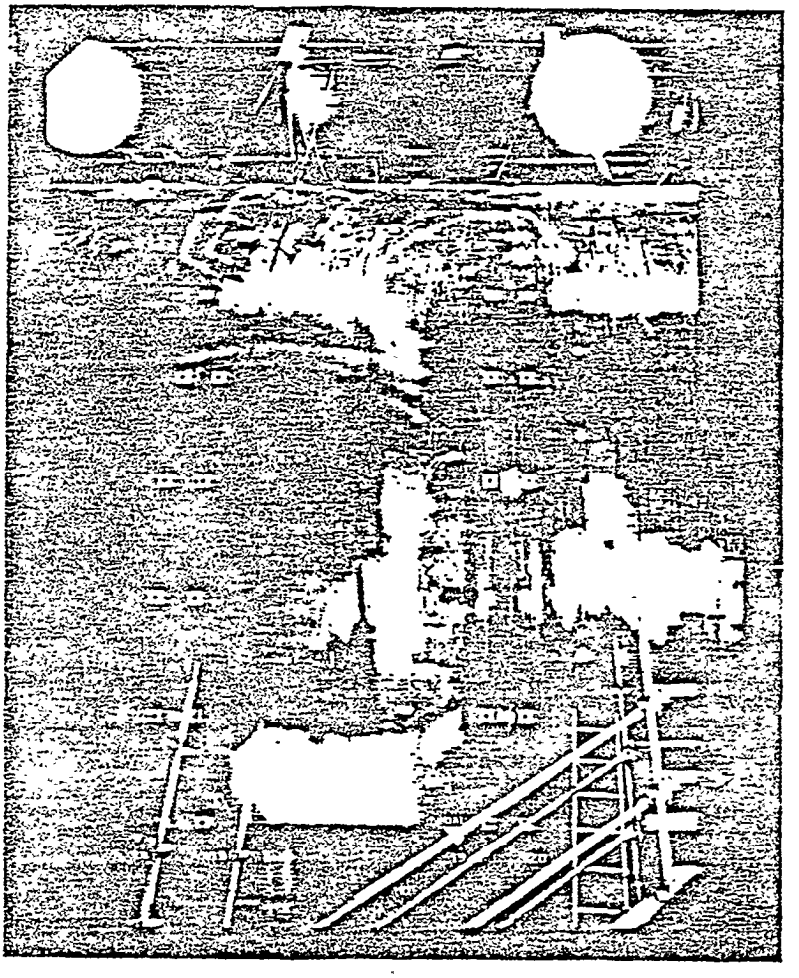


Figure 5 - Measurement Station Layout,
Showing Side of TRIDENT Hull

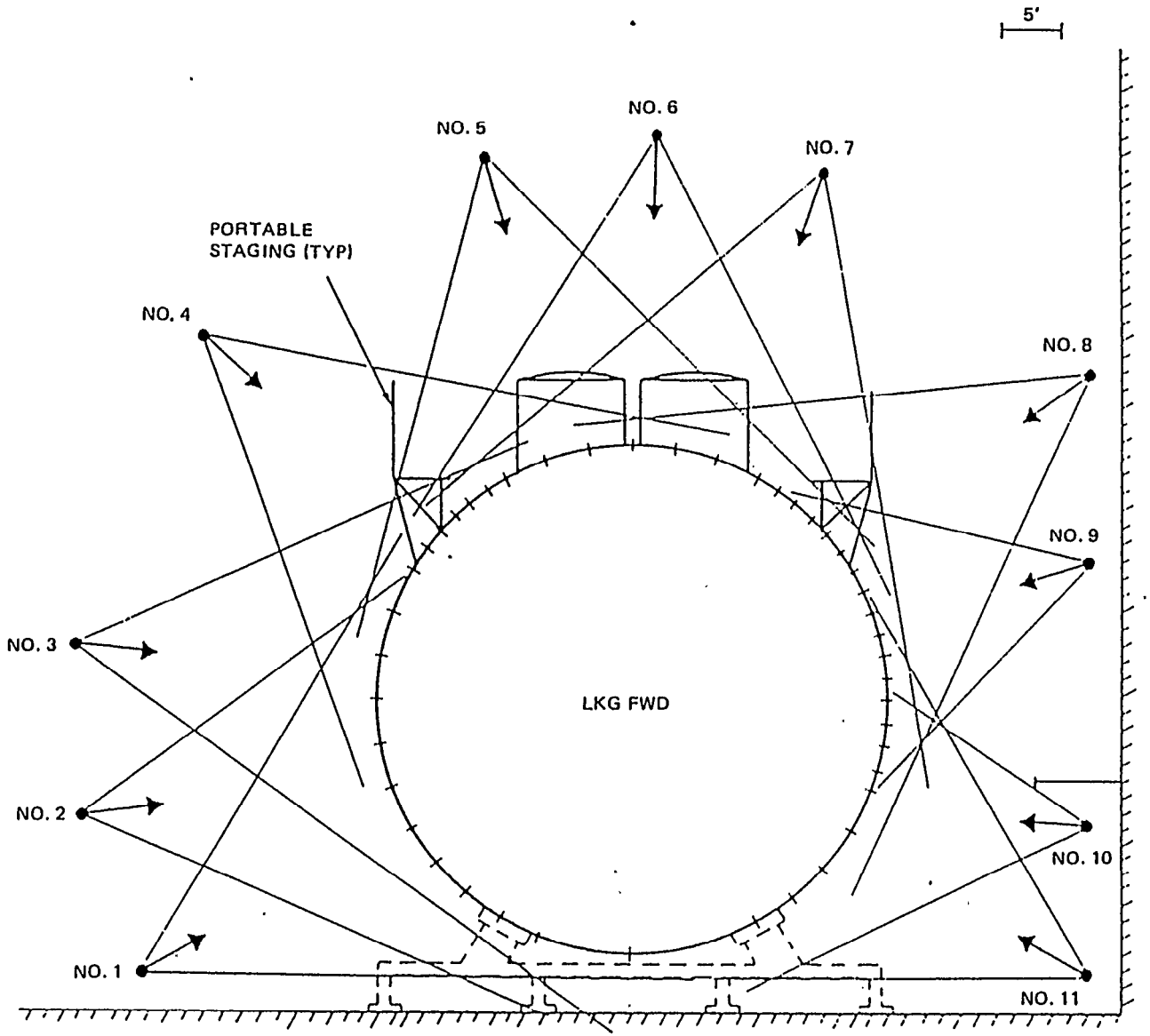


Figure 6- Photographic Plan for the Trident Hull Typical Transverse Section

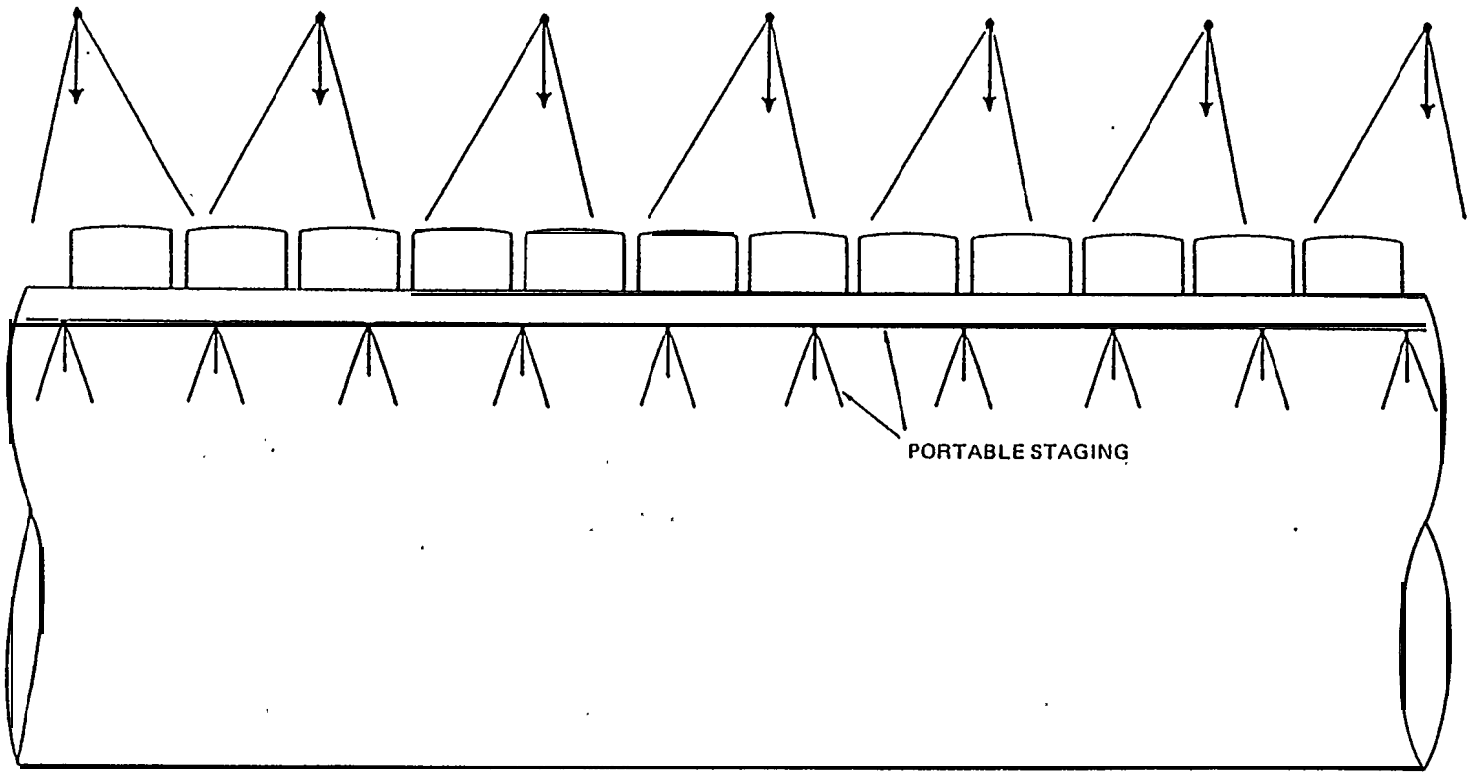


Figure 7 Longitudinal Section Showing Longitudinal Spacing of Photographs

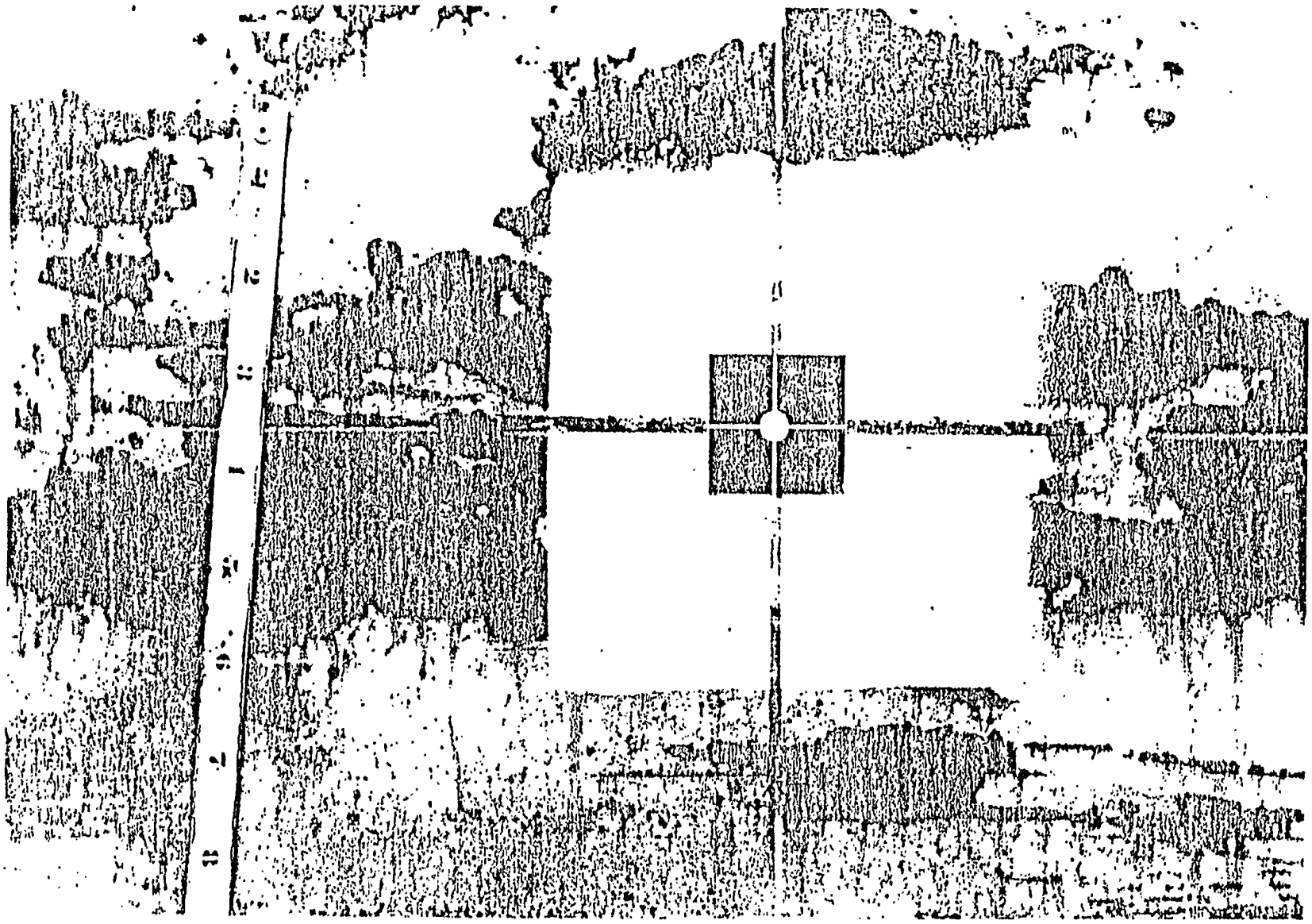
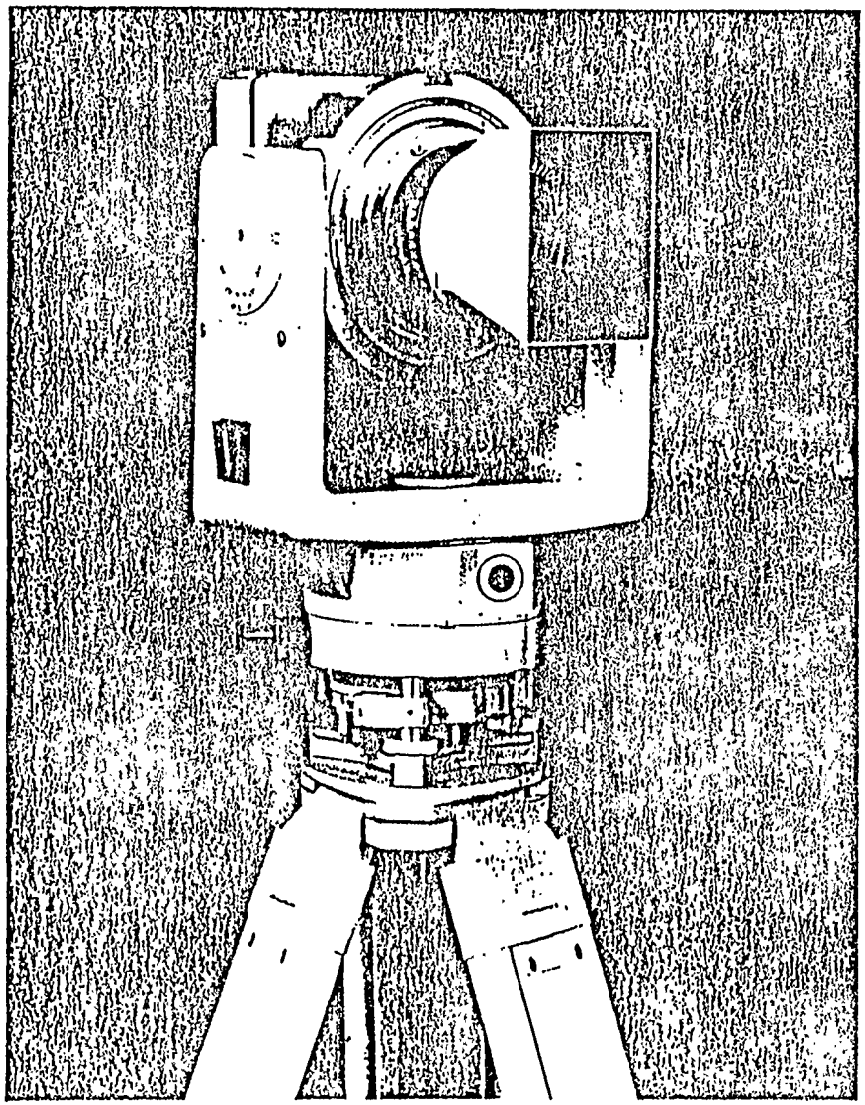


Figure 8 Blowup Showing Photogrammetric Target Affixed to the TRIDENT Hull



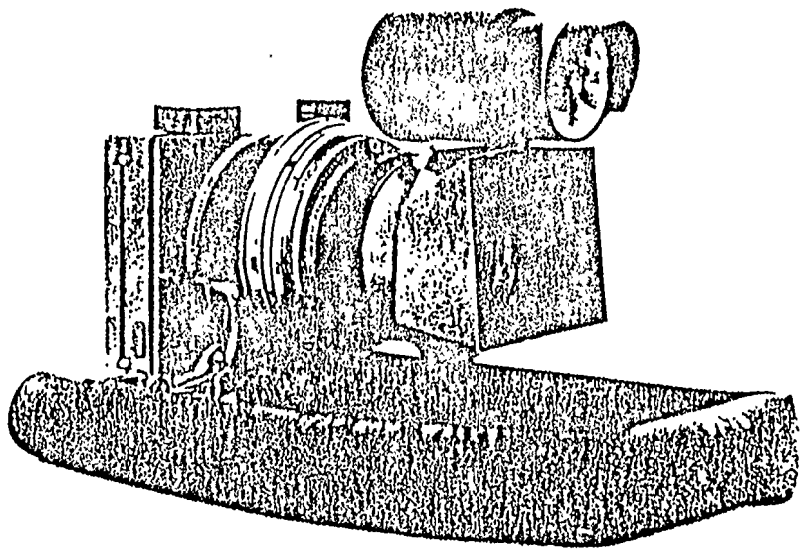


Figure 9
Wild P31 Universal Terrestrial Camera
Left: Mounted on Surveying Tripod
Above: Modified For Hand-Held Use

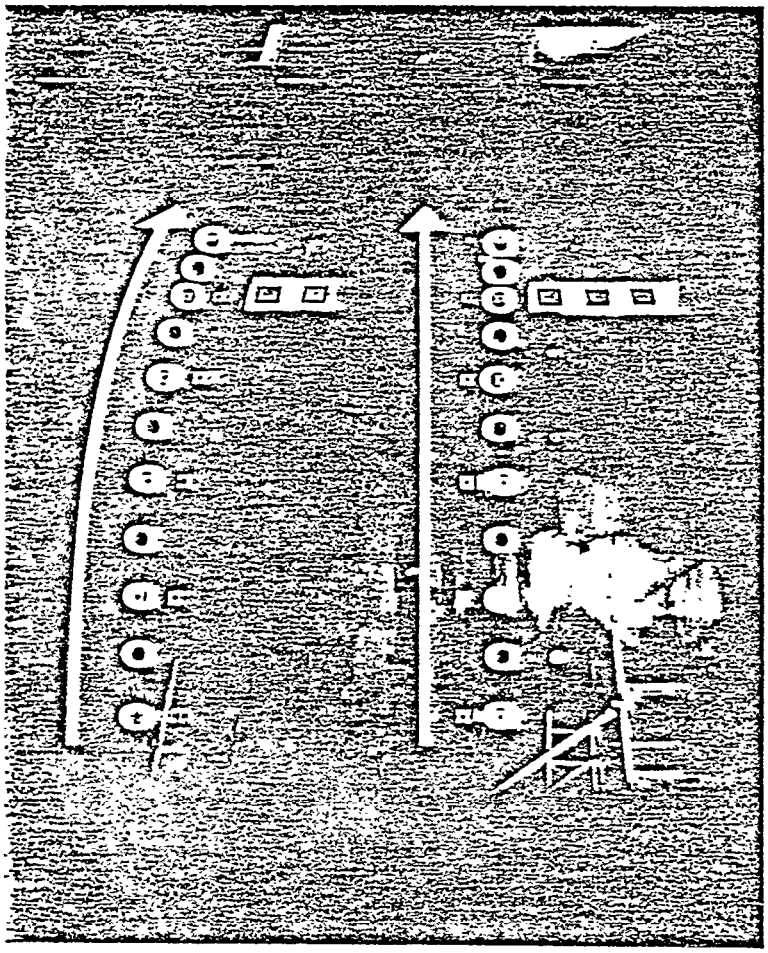


**Figure 10 Typical Glass pate Negative,
Showing Measurement Layout and Targets**

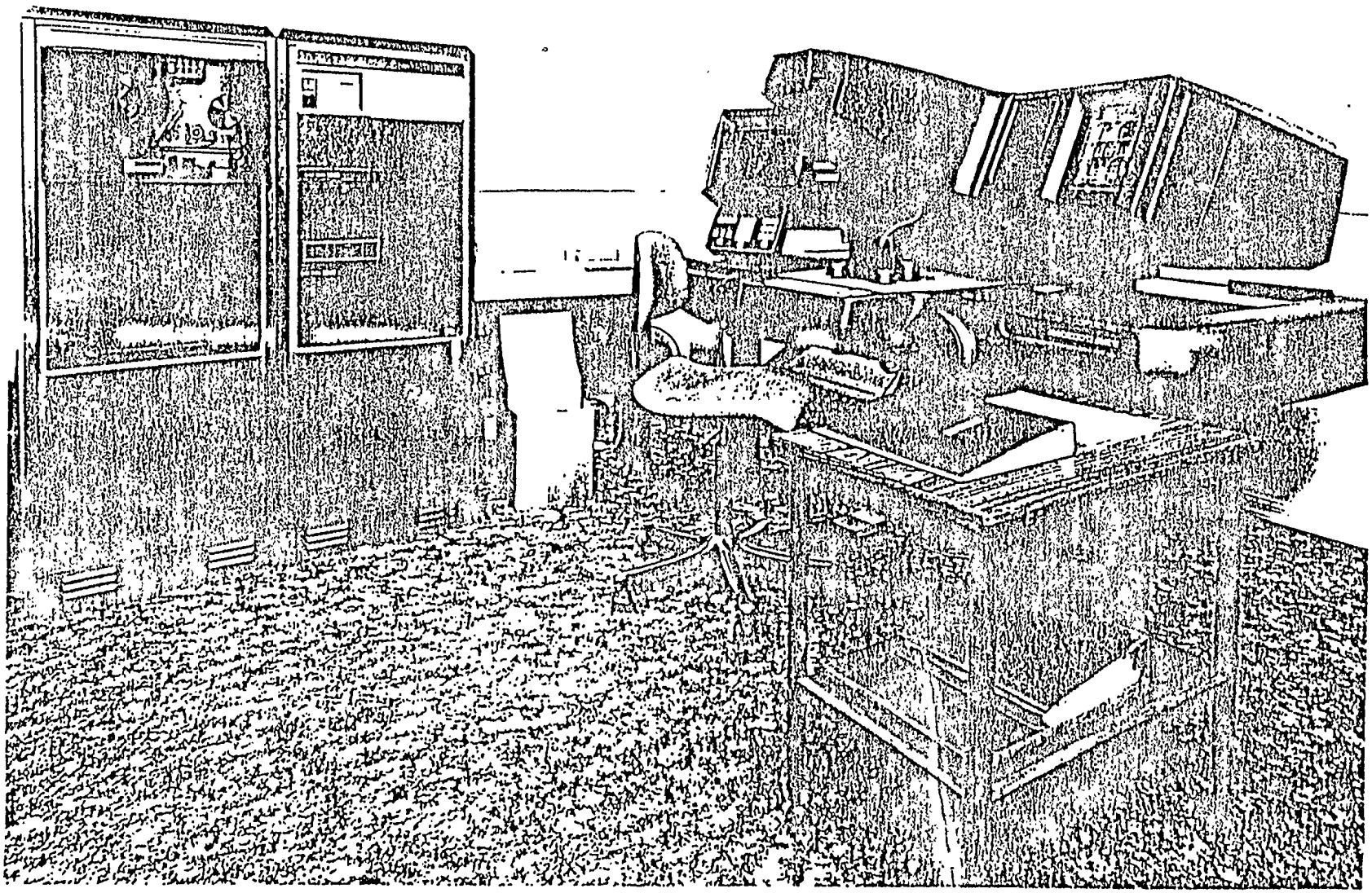


Figure 11 Wild Heerburg AC-1 Analytical Comparator
with Associated Computer System

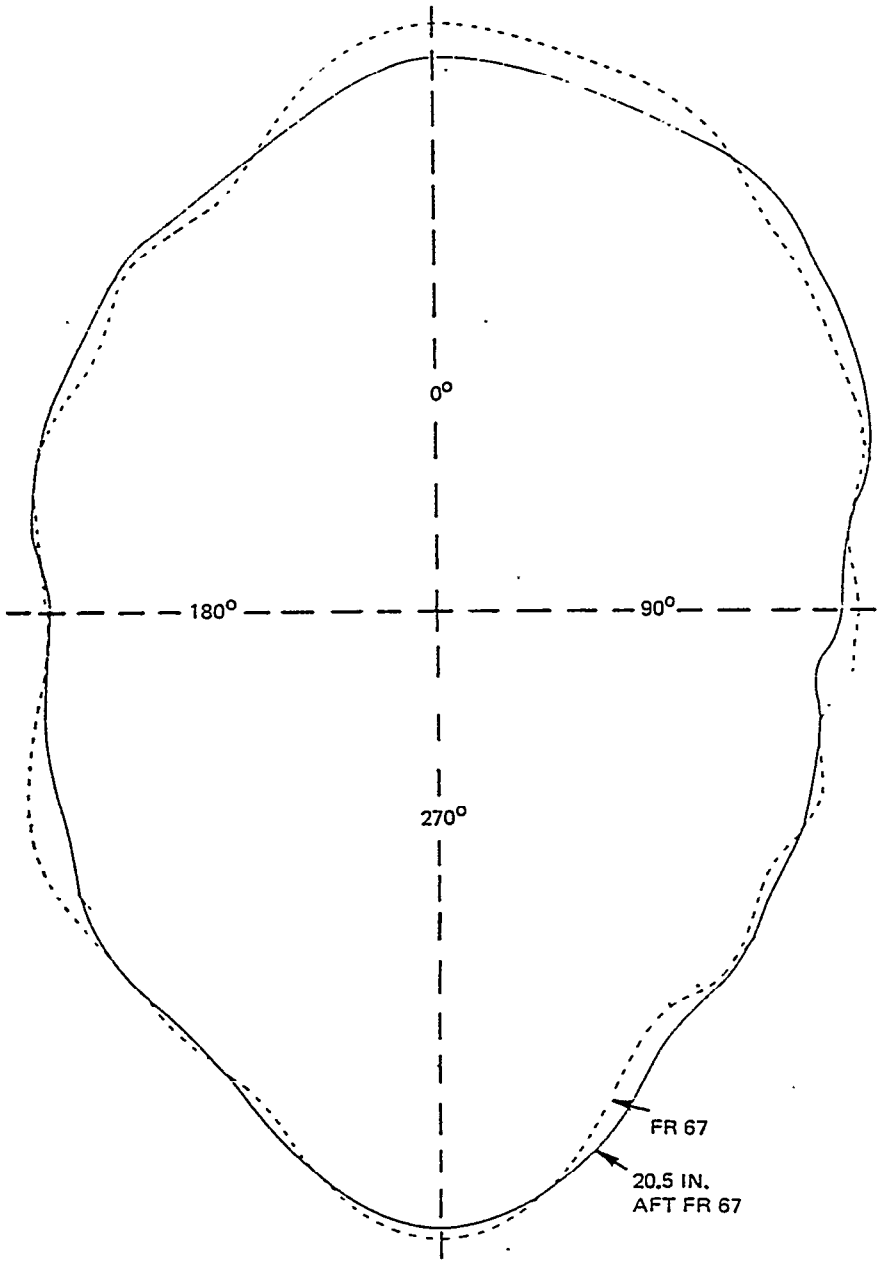


Figure 12 - Exaggerated Circularity Contour

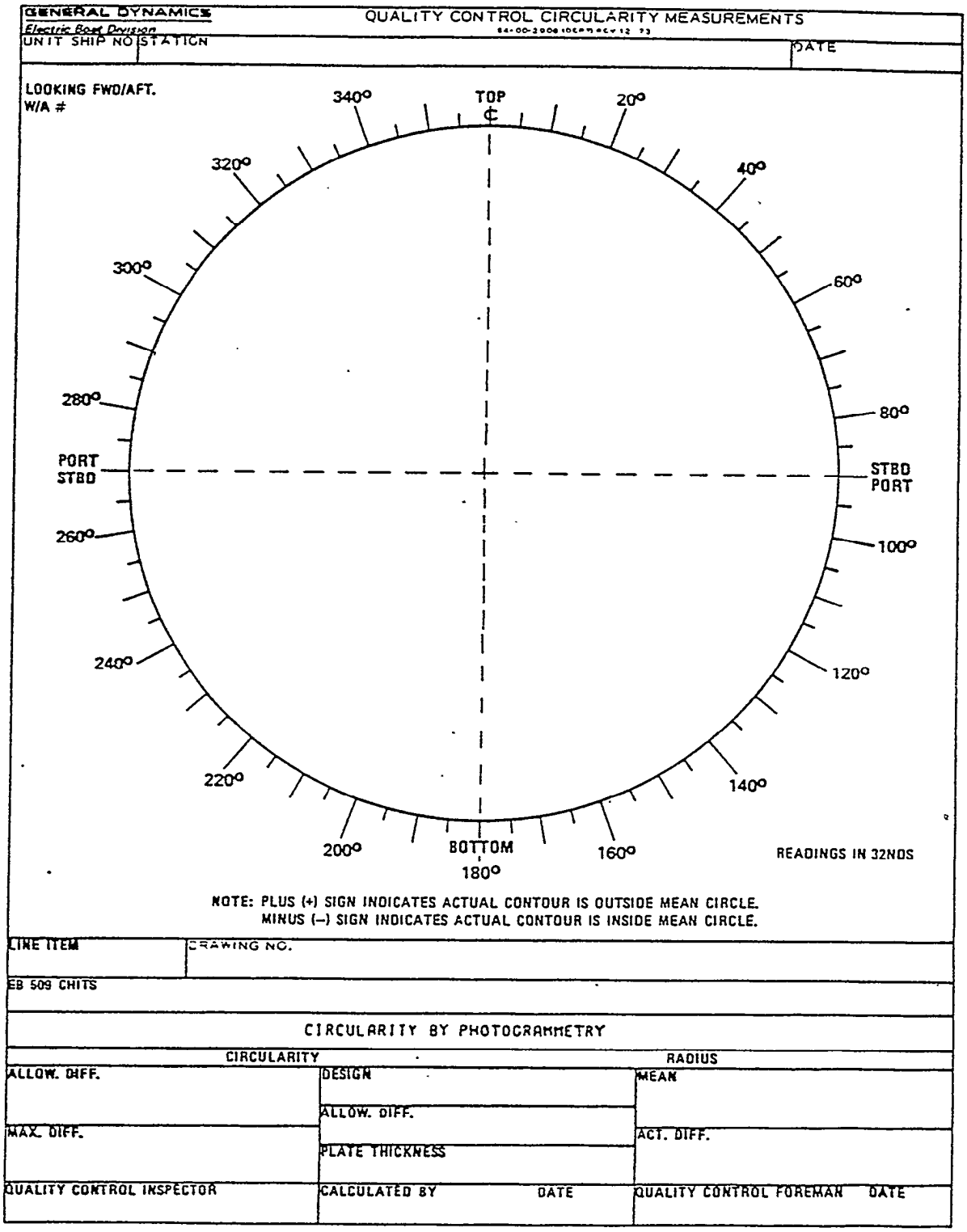


Figure 13 - Typical EBDiv Circularity Form Documentation

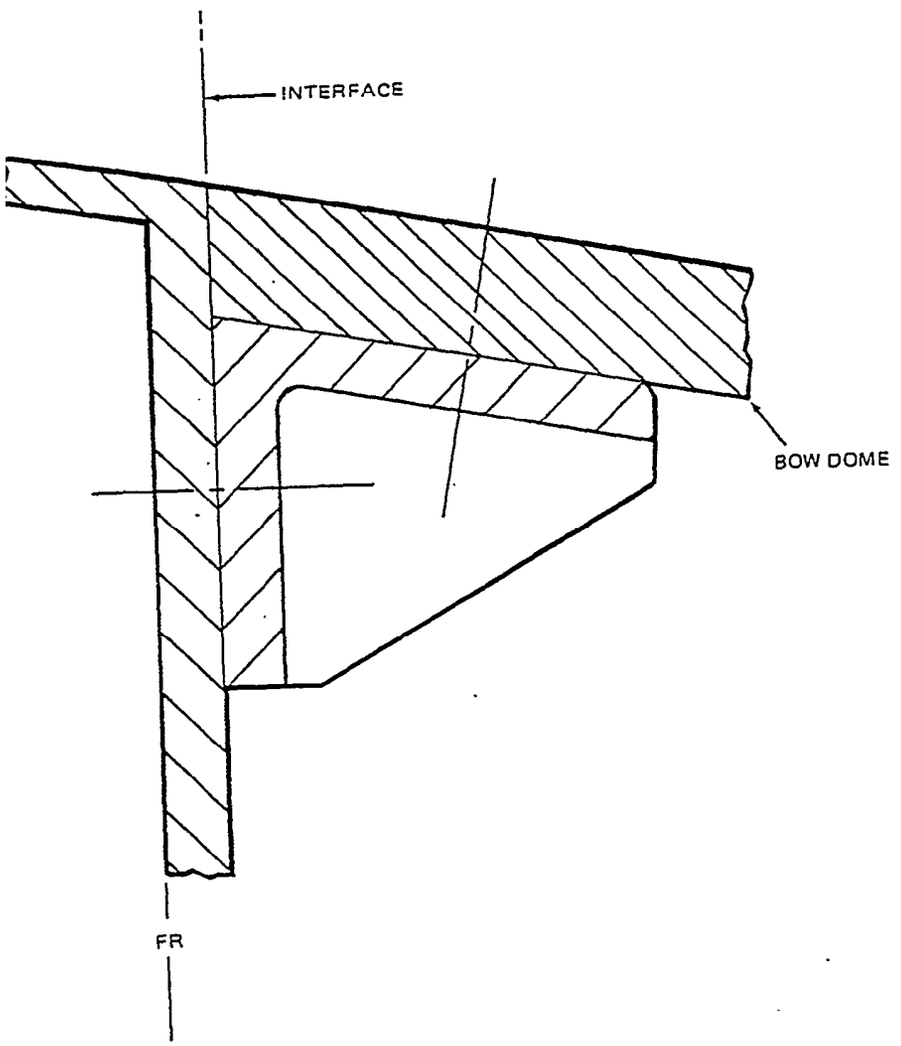


Figure 14 - Bow Dome Interface Attachment

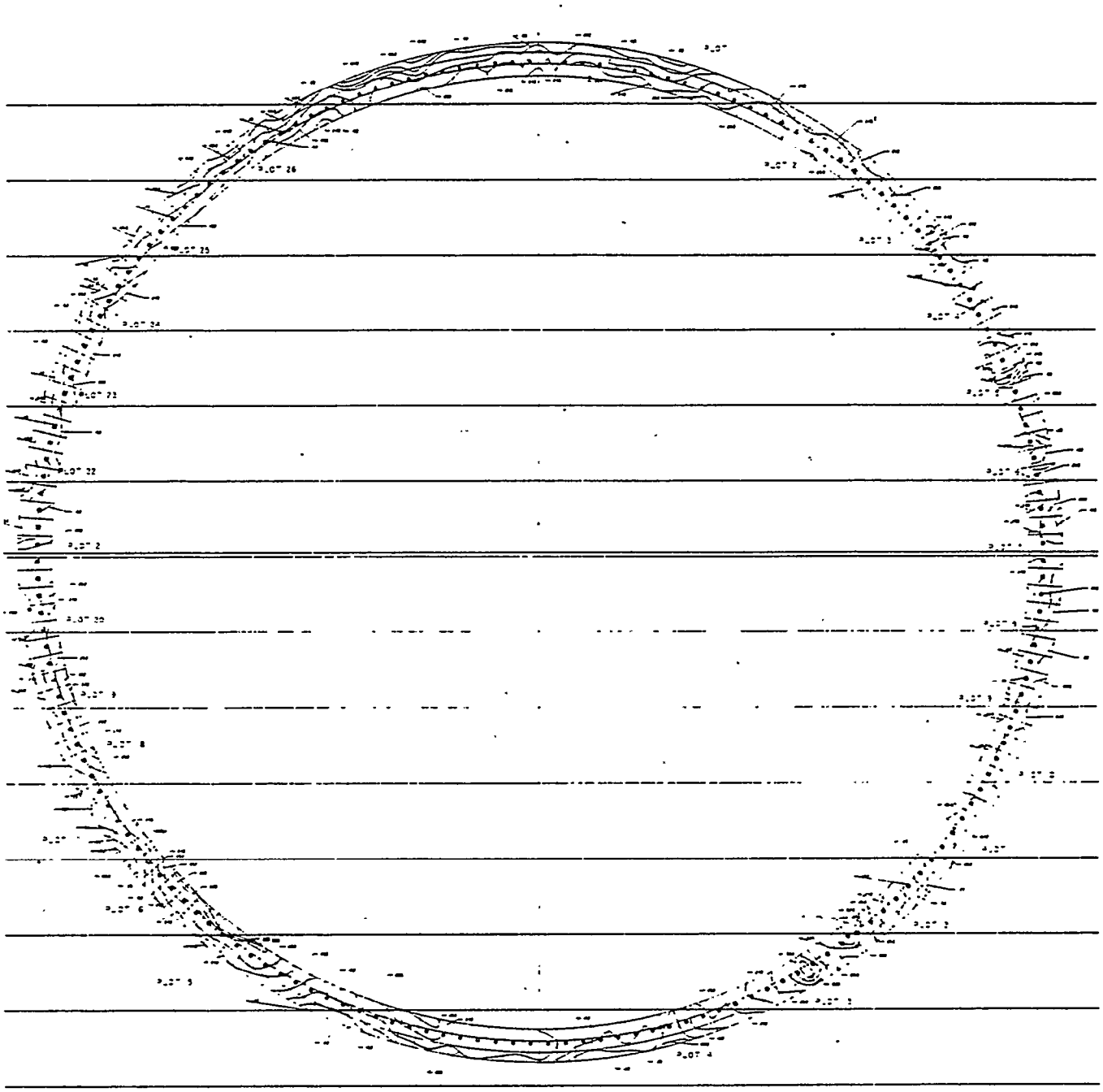


Figure 15 - Contour Profile of Non-Pressure Hull Interface

APPLICATION OF ZONE LOGIC AND OUTFIT PLANNING CONCEPTS TO OVERHAUL, MODERNIZATION, AND REPAIR OF U.S. NAVY SHIPS

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FEBRUARY 1985

APPLICATION OF ZONE LOGIC AND OUTFIT PLANNING CONCEPTS TO OVERHAUL, MODERNIZATION, AND REPAIR OF U.S. NAVY SHIPS

ABSTRACT

This paper presents the experience of Puget Sound Naval Shipyard in applying zone 1ogic and outfit planning concepts to the overhaul, modernization, and repair of an aircraft carrier, three cruisers, and a submarine. Procedures were developed to involve design, production, testing, and material personnel in the overhaul process from preplanning through completion of the production phase, with the resulting synergism and open communication. The systems approach was rep1aced with zone by stage sequenced work packaging with as much work as possible done off the ship. Computer Aided Design (CAD) and photogrammetry were applied to enhance preplanning and off-ship work.

Puget Sound Naval Shipyard's application of zone logic is drawn from the research managed by the Maritime Administration's National Shipbui1ding Research Program which has introduced the highly successful scientific shipbuilding systems developed in Japan. In brief, this concept represents a shift in logic from system to zone orientation.

INTRODUCTION

Historically, al 1 outfitting work in naval shipyards has been planned, scheduled, executed, and tested on a system by system basis. This method has developed for several valid reasons which include:

- Cost estimating and accounting
- Material estimating
- Ship operation and identification of problem areas
- System testing

While this method is acceptable and necessary for some shipyard functions, it is recognized that when repair work is actually accomplished it is not done solely on a system by system basis. Examination of any ship repair effort will Show that work accomplishment is based on several criteria, one of which is the functional system. Other considerations must include:

- Physical location of work
- Manpower requirements
- Other work required in the same location
- Similar work required in other areas
- Avail ability of material

These parameters are currently being considered and resolved by trade general foremen, with decisions made on a trade by trade basis when the work is actually started. Typically, the general foremen are faced with making these day to day decisions without knowledge or understanding of the overall plan for completion of the overhaul. This often causes items to be installed in an improper sequence which results in unnecessary rework.

Additionally, manufacturing a n d installation of numerous outfitting components have traditionally been postponed until the hull is available to the trades to determine their construction requirements. This process has resulted in relegating outfitting to a successor function completely dependent on hull constraints, with the natural effect of requiring peak manning and confined outfitting schedules.

Through the application of system oriented logic to actual work accomplishment, there is no allowance for an

objective, analytical examination of the best possible way to perform work, nor does it provide a method of feedback to increase the corporate know1edge of the shipyard. With the various systems being considered separately, trades often occupy space and compete for access simultaneously which minimizes the effect of production scheduling and control, and creates strained channel s of communication.

In looking at how outfitting work is actually performed, it is found that products are produced by procuring and/ or manufacturing parts and joining them together to create subassemblies. These subassemblies are progressively combined to produce a completed operational product. It becomes cl ear that the ideal way to subdivide ship repair and overhaul work is to focus on the needed parts, or interim products, that preoccupy the worker. Zone outfitting logic provides a scheme by which *work* is subdivided with interim products *as* the focal point.

Outfit planning addresses all outfitting components within a defined 3-dimensional space, and frees outfitting as much as possible from hull dependence and ship systems control. This provides the basis for grouping work into classes or problems so that common solutions can be applied regard-. less of product configuration and location, and planning installations in a logical sequence. The result of this scheme is that it permits most outfitting 'work to be accomplished earlier, and away from the ship to where it is safer, cleaner, and resources can be delivered to the worksite more economically. Overhaul durations can be reduced because of simultaneous accomplishment and coordination of outfitting and hull work which will minimize total shipboard construction time.

A zone is any subdivision of the planned work which best serves for organizing information needed to support outfitting at a particular stage of an overhaul. A zone might be a compartment or a portion of a compartment; it could include an entire superstructure or a component subassembly. The principle aspect of a zone is that it represents a means of dividing a ship's overhaul package into manageable, trackable blocks. Zone outfitting features three basic stages: on-unit, on-block, and on-board, coordinated by the "master bill of erection sequence."

On-Unit

On-unit outfitting is the assembly of an interim product consisting of manufactured and purchased equipment (components). It includes all but a final coat of paint. A unit is composed exclusively of outfitting materials (pumps, motors, mechanical and electrical interfaces, and a common foundation including false floor ribbing, etc.). The on-unit outfit planning is separate from the main hull structure. Units can be categorized as (a) functional, (b) geographical, or (c) combination.

Functional units consist mainly of components necessary for the operation of something, e.g., a heat exchanger assembly. It is generally associated with one system (potable water and freshwater units, water distilling unit, F. O. purifier unit, refrigeration plant unit, etc.).

Geographical units provide passage(s) for systems. Such units are assembled together to insure that they will fit onboard (pipe, HVAC, or wireway passage(s) on deck unit, accommodation unit, engine room unit, etc.).

Combination units include more than one system built together and lifted to installation site (pipe/HVAC/wireway/ machinery/associated foundations, grating/false floor attachments, handrails, etc.).

On-unit outfitting should be given the highest priority even though there is some impact on hull construction progress because assembly is performed in shops which provide ideal climate, lighting, and access. Shop work increases the opportunity for improved safety and higher productivity. Outfitting on-unit has less impact on the progress of hull structure as opposed to on-block outfitting.

On-Block

On-block outfitting is the installation of outfit components, or even a unit, onto a hull structural assembly or "block" prior to its erection. It is the next best alternative to outfitting on-unit. It includes all painting except a final coat and that paint omitted to anticipate welding of butts and seams. On-block outfitting requires coordination between hull, mechanical, ventilation, and electrical systems supported by material (supply), planning and estimating, and scheduling. A "master bill of erection sequence," developed by engineering, production, planning and estimating, and supply. is controlled by scheduling (via work order task assignment). This identifies the sequential road map in which systems are installed. Engineering lists systems and components to be involved on-block and provides the work package; production assists in the design planning stage designating the construction envelope and supports engineering on preferred design applications; planning and estimating defines the work packages by crafts and sequences the construction flow by landing dates; and material (supply) has the integral task of coordinating the material flow based on the "master bill of erection sequence" and only stages the identified materials required to support production flow.

On-Board

On-board outfitting includes, and ideally should be limited to, the connection of units and/or outfitted blocks, final painting, and test and trials. It necessarily includes some installation of outfit components, in a hull at a building position or outfitting pier, which cannot be productively incorporated "on-unit" or "on-block."

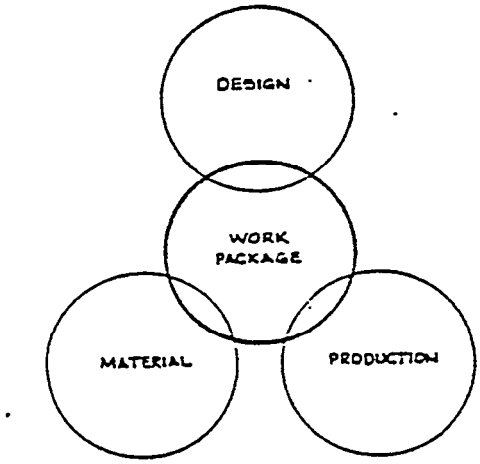


Figure 1
The work package acts as a common 1 ink to integrate work requirements.

One method used to organize information to support outfit planning is the work package concept. This is a conceptual approach that allows information from design, material, and production to integrate so that the various shipyard departments have a common understanding of how the ship will be overhauled. A work package is the common link to communicate a "build strategy" so that a definite increment of work with al located resources needed to produce a defined interim product is identified. A work package is al so a definition of components of the various funtional systems in a particular zone at a specified time of repair. This concept is extremely beneficial for staging material for delivery to a worksite.

Preoutfitting should not be confused with zone outfitting. Preoutfitting is usually planned by allocating resources to activities associated with ships'

systems in related large structural sections. Access is improved over conventional outfitting but components are still installed on a systems basis with great dependence on hull availability. Trades still compete for time and space, using unchanged methods, and material flow to the worksite is not optimized. Savings in total mandays and overall building period are limited because the only real difference between preoutfitting and conventional outfitting is where the work takes place. Preoutfitting of a very large structural assembly can be equivalent to outfitting a small ship of equal tonnage by conventional methods. Zone outfitting takes the additional step of freeing outfitting from hull dependence and systems control.

Puget Sound Naval Shipyard began its experiment with outfit planning by sponsoring two-day training seminars to all shipyard upper and middle level managers in May of 1982 and January of 1983. These seminars provided the necessary background to gain the shipyard-wide support needed to successfully carry out test cases for outfit planning. In February of 1983, while understanding that zone outfitting logic applied to new' construction, the shipyard Planning Officer and Production Officer (with the support of the Shipyard Commander) called for the establishment of an Outfit Planning Group to determine if and how zone outfitting logic might be applied to the type of repair/overhaul work accomplished at Puget Sound Naval Shipyard.

OUTFIT PLANNING GROUP

Most shipyards that have adopted zone logic have completely restructured their organizations to reflect the concept. Since this was an exploratory project for Puget Sound Naval Shipyard, and because of its potential far reaching impact on the methods and procedures used within the shipyard, it was determined that an Outfit Planning Group with representation from all shipyard departments was necessary to ensure total evaluation. This type of approach gave the shipyard the best opportunity to assure familiarity with all problems and solutions, and gets all departments involved in the planning and sequencing of al 1 operations from issue of planning documents through completed installation testing.

The Outfit Planning Group formed at Puget Sound Naval Shipyard consisted of representation from the following departments:

- Combat Systems
- Design
- Overhaul Superintendent
- Planning and Estimating
- Plant Engineering
- Production
- Progress
- Scheduling
- SUPPlY
- Test Engineering

With this cross section of ship repair departments, the integration of outfit planning to ship repair received overall review to assure organizational coordination and agreement. The Outfit Planning Group became the forum by which the technical requirements and practical applications are integrated to develop a common "build strategy."

As shown in Figure 2, a core group evolved which had more direct involvement in the daily function of accomplishing repair work, and was in an optimum position to analyze the affects of zone logic *on* individual and shipyard methods. The core group interacted among themselves, and within their *own* departments, to examine, resolve, and promote the application of new approaches developed from zone logic. Corroboration with the periphery departments is maintained when their special - ties are involved and at periodic verification reviews. This process proved to be reliable by allowing the smaller group to efficiently operate

and still sustain total shipyard involvement. This forum is at all times tasked to be creative in the analysis of the technical and manufacturing processes to stimulate smarter approaches during the project evolution.

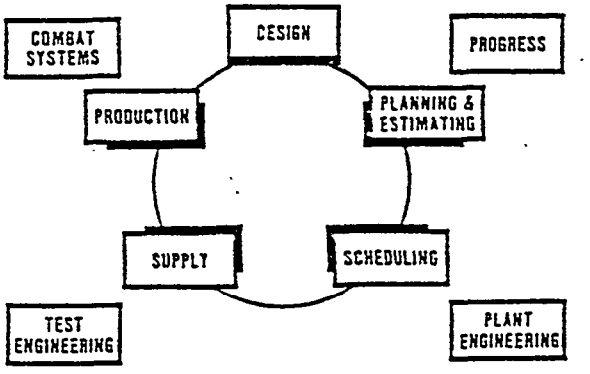


Figure 2
Outfit Planning Group

The Outfit Planning Group uses a unique dual management posture which reflects the work emphasis shift from the planning phase to the production execution phase, and the direct 1 ink between design requirements and production applications. These two leadership positions are represented by the Design Division (chairman) and Production Department (zone manager). influence of design requirements paramount in the early planning process, the chairman leads the Outfit Planning Group's efforts in defining work zone parameters. When the work is identified, the zone manager then takes the lead to direct the group's sequencing to reflect production needs. During the transition period between defining and sequencing, both work together to adjudicate the exchange of information between the various departments such that a fully integrated, zone oriented build strategy is proceeding. With zone logic in mind, the chairman is responsible for providing production with a sequenced work package, and the zone manager is responsible for executing the work package. Both are responsible for assuring all the requirements and methods are coordinated and supported.

In order for the Outfit Planning Group to assimilate and associate all the information to implement zone logic concepts, a process framework was prepared to operate with. The following procedure organizes all' the input related to the project and generates the master bill of erection sequence.

- Systems drawing preparation
- Composite drawing preparation
- Composite/system drawing analysis
- Work package identification
- Work package sequence
- Work package instruction

System Drawing Preparation. In accordance with current policy, traditional systems drawings are prepared and provided to the installing activity.

Composite Drawing Preparation. Using the data from the various systems drawings, a composite drawing is prepared to delineate all components to be installed within the defined zone boundaries, and existing shipboard components to be interfaced. Depending upon the complexity of the systems in the zone, the composite drawing will consist of plan views at various levels, and elevation views of particularly congested areas. This drawing provides a means to identify and correct potential interference items while still in the planning phase. More importantly, it is used as a tool by the Outfit Planning Group to trunk systems for the simplest fabrication and installation sequence.

Composite/System Drawing Analysis. The Outfit Planning Group performs a detailed analysis of the' drawings to form an overall profile of the task. The analysis includes such items *as:*

- System requirements
- Trade involvement
- Material requirements
- Testing
- Facility impact
- Certification requirements

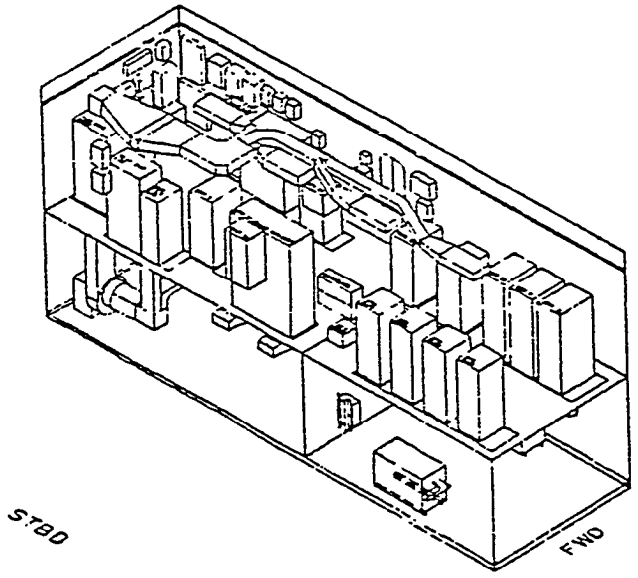


Figure 3
CAD composite depicting layering of equipment
and air conditioning within hull block.

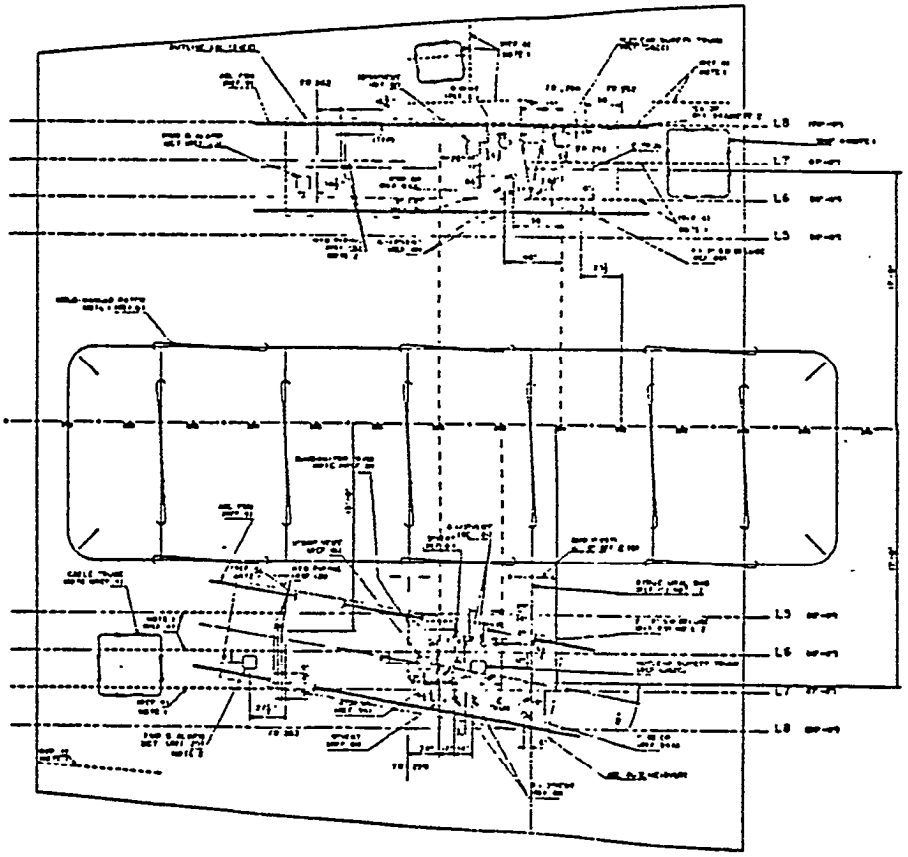


Figure 4
Composite view identifying common work procedure
for onboard site preparation.

Work Package Identification. During this phase. the Outfit Planning Group divides the task into segments of work in order to focus on the coordinated interface between planning and production requirements. It is at this time that the various trades provide input as to their particular methods of accomplishing specified tasks. These various inputs are coordinated and incorporated through an iterative process to accommodate decisions and commitments reached to form a final work package definition.

Work Package Sequence. The Outfit Planning Group arranges the work packages into a logical flow of work which represents the project build strategy. While this function is separate from work package identification, it is an integral element of the iterative decision making process to arrive at a final work package.

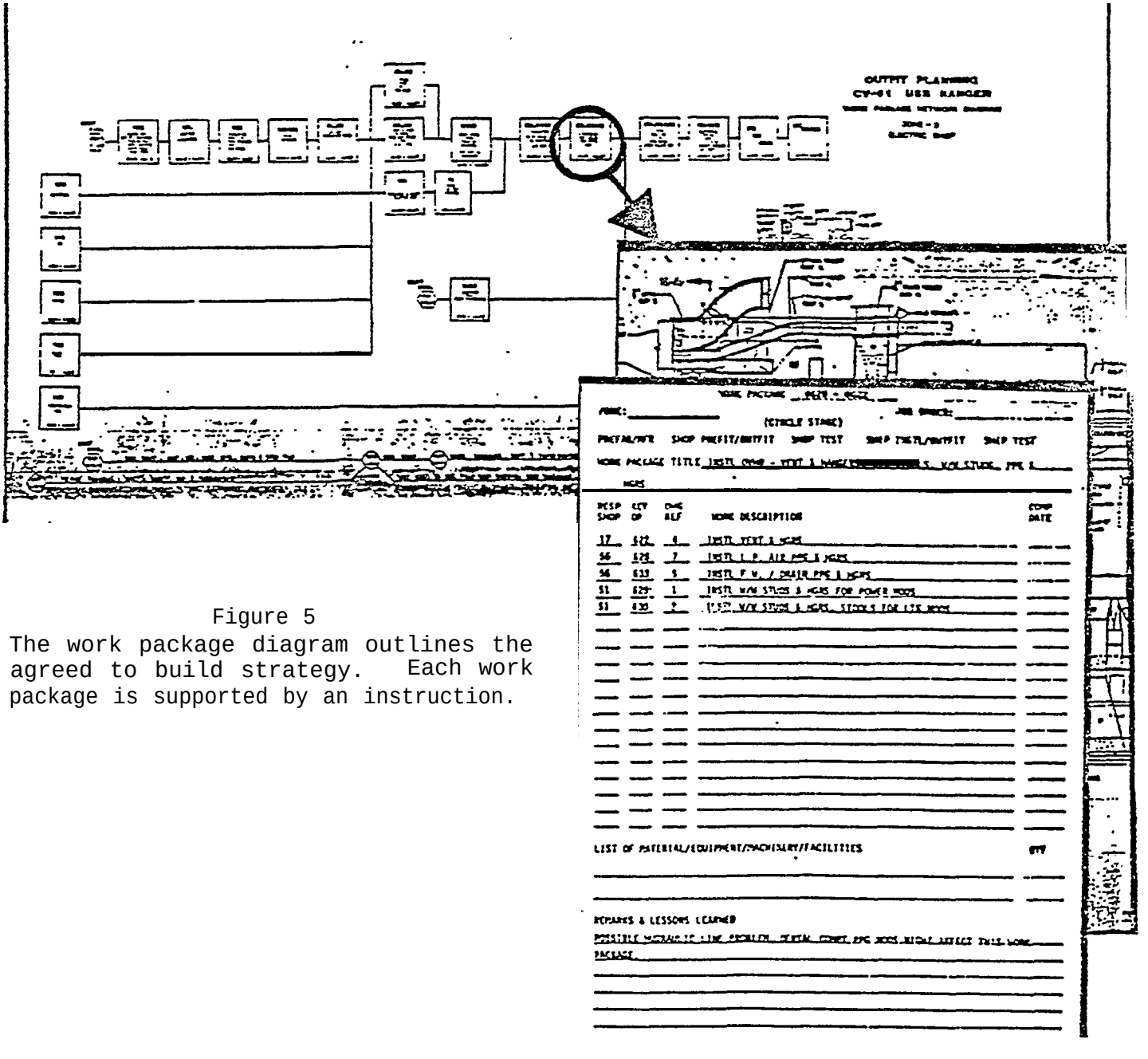


Figure 5
The work package diagram outlines the agreed to build strategy. Each work package is supported by an instruction.

Work Package Instruction. Once the work packages are identified and sequenced, the Outfit Planning Group prepares an instruction for each work package. This instruction is a synopsis of the work required to accomplish the work package and includes such information as:

- Work description
- Key shop
- Job order and key op
- Needed resources
- Highlighted sketch

These sheets are assembled into a book, and issued to the zone manager and involved trade foremen to be used as a tool to manage the project resources, aid the waterfront decision making process, and measure project progress.

CASE NO. 1: USS RANGER (CV 61)

The complex overhaul of the aircraft carrier USS Ranger (CV 61) provided the first opportunity for Puget Sound Naval Shipyard to determine how zone outfitting concepts could be adopted. Two shipalt packages were targeted for analysis. The areas selected furnished excellent opportunities to examine a good mix of systems work in two typical, but divergent types of overhaul tasks. The first task involved the construction and installation of a new deckhouse which closely resembles new construction processes (on-unit and on-block); while the second task accompli shed complete reoutfitting of an existing space which represents typical overhaul *work* (on-board).

In order to concentrate on zone logic concept application and provide reasonable data for evaluation, the Outfit Planning Group limited it's focus to the specific compartments involved, and did not attempt to sequence work once a system exited the defined tone. On the other hand, any non-related system "passing through" the zone was included in the build strategy.

With all the design, planning, and production work being accomplished at Puget Sound Naval Shipyard, the opportunity to open cross comnunication between the various departments was taken. Production Department concerns and needs were expressed to the design division so that documents could be enhanced to aid production methods. At the same time, design requirements were being explained to production personnel to aid their understanding of the projects. In a few cases, production personnel were loaned to the Design Division to prepare the drawings which were to be used for these tasks.

When the projects were ready for production to begin, a meeting of all involved trades was called to explain the build strategy. General foremen, foremen, and mechanics were represented so that all parties would have the same understanding of how work was to be accomplished. Each was also encouraged to provide input that would improve work sequencing analysis methods *for* future work.

Zone 1: Close-In Weapon System Deck-'house

This project consisted of fabricating, outfitting, and attaching a new 24'x26'x8'26-ton deckhouse to the outboard side of the existing island to accommodate a new defensive weapon suite. It required the coordination and sequencing of 14 various systems, and integrating these systems with the hull block construction. Preparation of the shipboard site was an additional major element to be incorporated into the build strategy.

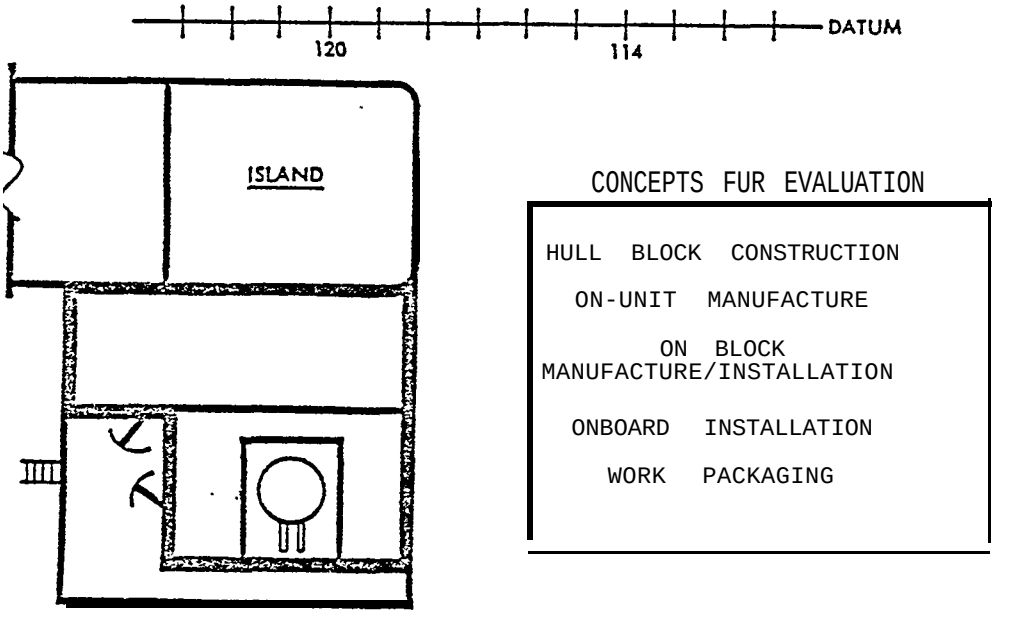
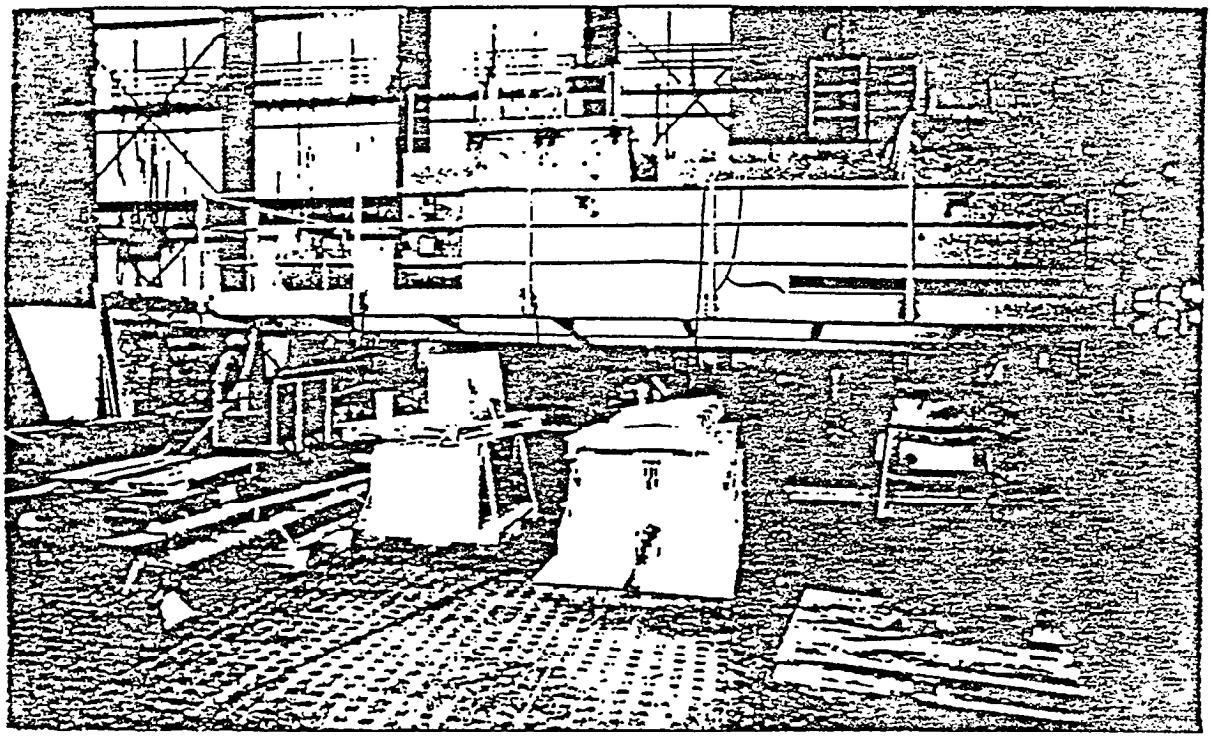


Figure 6
USS Ranger Close-In Weapon System

Through the use of the composite drawing, the hull block/outfitting interface areas were identified and incorporated in the structural construction phase of the deckhouse to support subsequent outfitting installations. Al 1 system penetrations and underdeck foundation stiffening in the new structure were detailed on the structural prefabrication drawing so that they could be included during the initial construction of the deckhouse. This process allowed for accomplishing common work procedures regardless of the particular system and independent of when that system is to be installed.

As the hull block was being constructed, the required manufactured components were being fabricated in the shops using the appropriate system drawings for details. This opened up the idea of accomplishing outfit component manufacture simultaneous with and independent from structural fabrication.

Space was provided in the structural shop to place the deckhouse for outfitting and on-site material laydown during the on-block phase. In order to coordinate hanger locations, the trades used a “put-up/take-down” technique to install hangers so that all welding could be completed and clear access provided for thermal insulation application. The deckhouse was then ready for install a-tion of the components to proceed according to the sequence developed.



F i g u r e 7
On-block outfitting of USS Ranger close-in weapon system deckhouse.
Components staged and accessible to trades.

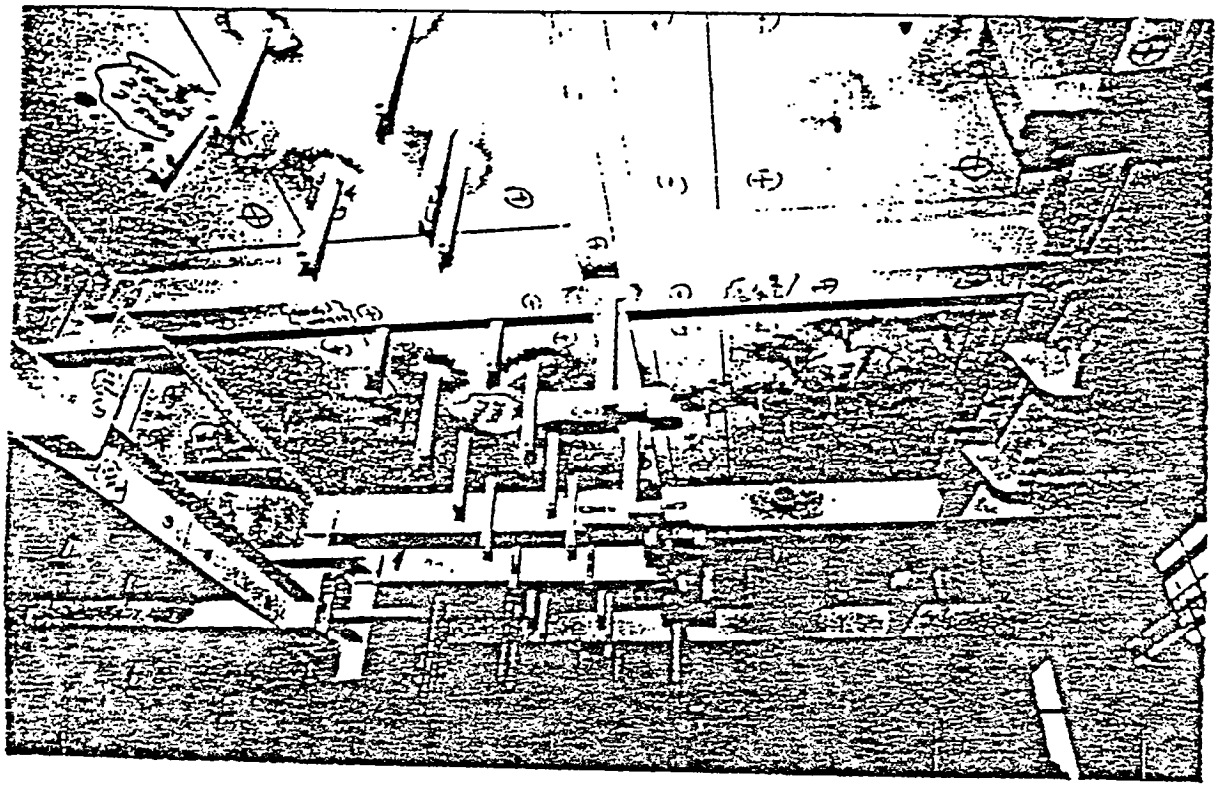


Figure 8
Hangers, brackets, and foundations located and installed.
Structure accessible for insulation application.

It should be noted that the deckhouse outfitting was 50 percent complete prior to ship arrival. This illustrates the impact that outfit planning can have on overhaul durations. One major factor that precludes complete outfitting of a new structure away from the ship is the allowance necessary for attachment to the existing structure. For the CV 61 deckhouse, a 24″ strip around the attachment plane was left empty to allow clearance for welding when the house was attached to the ship.

At the ship's arrival the site preparation phase-was accomplished in which the existing surface was cleared of interferences and prepared for accepting the new structure. To support the concept of accomplishing as much work in the shop as possible, photogrammetry was used to define the contour of the prepared island enclosure bulkhead. The data from the computer readout was transferred to the mating edge of the new deckhouse which allowed the structure to be trimmed while still in the shop.

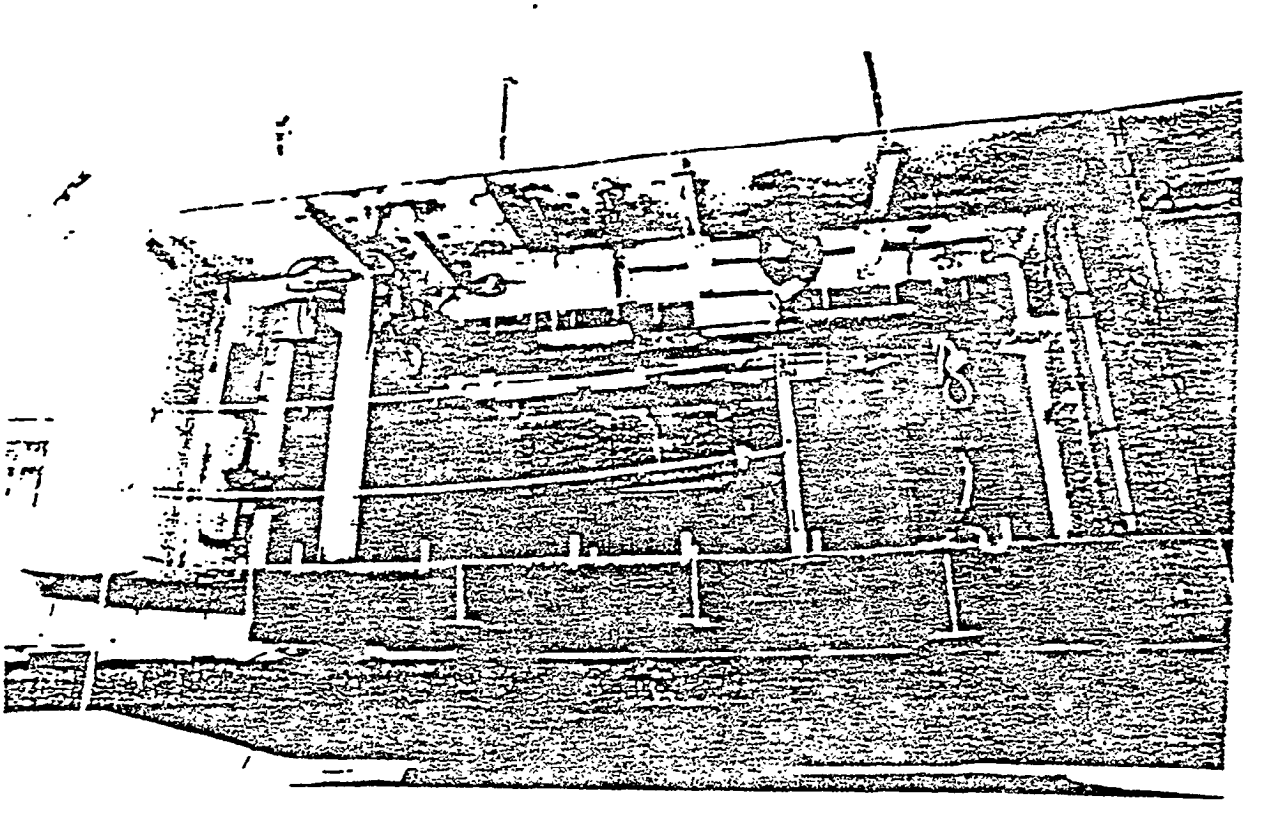


Figure 9
USS Ranger deckhouse transferred to site with outfitting 80 percent complete and mating edge trimmed. A 24″ strip around the mating edge is left clear to facilitate site installation hot work.

Forty-four days after the ship's arrival, the new deckhouse, with 80 percent of the outfitting components installed, was attached to the existing ship. The fit-up interface between the new and existing structures averaged ± 1/16" which allowed production welding to begin within hours after the initial lift, and tied up pierside cranes for only four hours.

After the structure was welded in place, the remaining outfitting components were installed and interfaced with systems transiting the zone boundary.

Zone 2: Electrical Shop Upgrade

This project involved the complete reoutfitting of the existing Electric Shop with updated equipment to improve shipboard electrical repair capability. The shop is located on the third deck at centerline and represented the more typical type of overhaul work encountered by a repair facility. Interfacing of on-unit concepts with existing shipboard conditions provided the peculiar challenge of this project. It required the sequencing of nine different systems to be modified, and coordination of the affects of these on the existing systems.

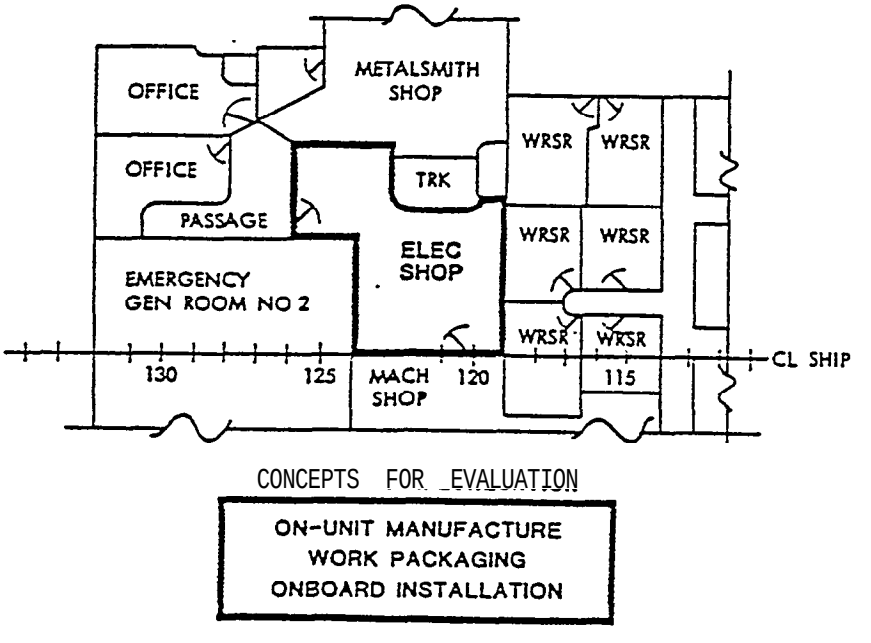


Figure 10
USS Ranger Electric Shop

With' this project, the composite drawing was used to identify the interrelationship between the new components being installed, and the existing components being either removed, modified, or remaining. Preparation of the composite required extensive effort to correctly delineate the existing system location and configuration. With the aid of the composite, a number of system components that would have normally been fabricated and routed onboard were designated for manufacture in the shop prior to the ship's arrival.

The concept of on-unit fabrication of the components was modified by permitting key piece trim allowance to accommodate final interface alignment with existing components. This procedure all owed for 90 percent of the particular run to be fabricated in the shop with the remaining 10 percent to be fitted onboard.

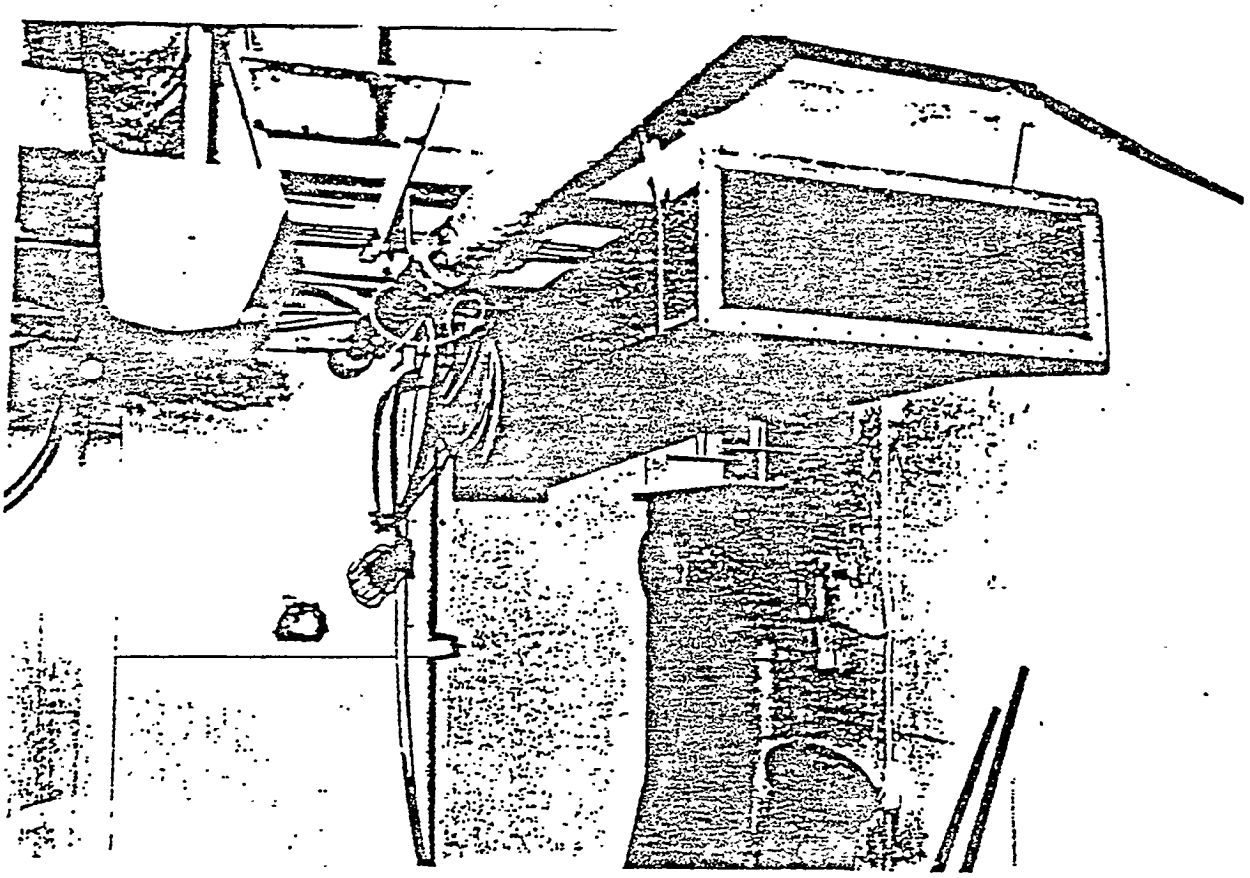


Figure 11
Integration of new components with existing systems requires extensive coordination.

The Electric Shop task concentrated on the on-unit and onboard work concepts of zone logic and emphasized the trade coordination necessary to support the planned sequence of removal and installation. This task had a number of problems related to Government Furnished Equipment (GFE), but the 'shipyard was in a much better position to identify impact and coordinate solutions because it had a definite planned approach for the production effort.

CASE NO. 2: USS ARKANSAS (CGN 41)

A selected restricted availability for the cruiser USS Arkansas (CGN 41) provided an excel lent opportunity for Puget Sound Naval Shipyard to expand on the outfit planning concepts initiated on USS Ranger. The planned availability is to be a short duration overhaul primarily for the purpose of installing Tomahawk weapon capability. This provided the opportunity to use the zone logic application to a complete ship alteration and it's affect on the entire ship.

Other variances from the Ranger task to be considered and evaluated are the use of systems drawings prepared by another design agent, and the use of computer aided design (CAD) to prepare the composite drawings. Incorporating these variances into the zone oriented planning process previously discussed represents a significant step forward for Puget Sound Naval Shipyard's application of outfit planning.

The Tomahawk project consisted of fabrication, outfitting, and installation of a 40'x12-1/2'x16' 40-ton equipment module below the main deck; installation of armored box launchers on the main deck; and, modification of various electronic control throughout the ship. This task profile offered the ability to expand on new construction and existing space modification techniques began on USS Ranger.

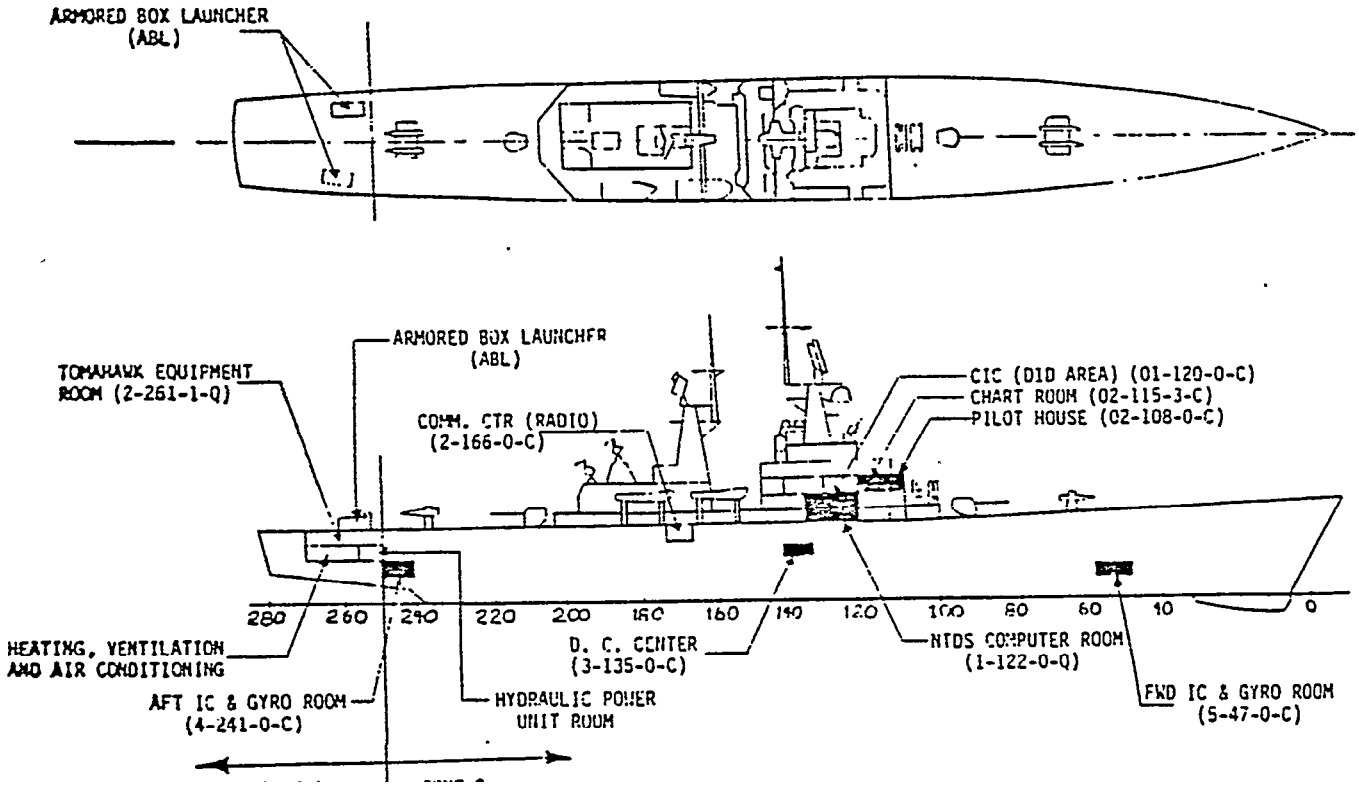


Figure 12
USS Arkansas Tomahawk Installation

Employing systems drawings prepared by design agents for use by other shipyards' production department is a situation that will be contended with more frequently in the future. The constraints of this condition on outfit planning application is a prime area of evaluation for the USS Arkansas project. Methods of introducing production input to these documents are being examined to allow timely response and substantial familiarity of the project for the installing activity. The Arkansas Outfit Planning Group was able to have some input to the structural prefabrication drawings, but drawing and production schedule compression precluded the Group's attempt to influence component systems drawings to provide a totally interrelated drawing package reflecting the build strategy.

The composite drawings used by the USS Ranger Outfit Planning Group were prepared by hand which was Labor intensive and time consuming. In order to reduce cost and time for composite drawing preparation, the USS Arkansas Outfit Planning Group initiated the *use* of CAD for this effort. Not only was time reduced, but because of the "layering" capabilities of CAD, the flexibility of the composite drawing was greatly enhanced to al low view rotation, enlargement, and highlighting.

Based upon common work and schedule problems, the USS Arkansas Tomahawk project was divided into two zones. The first zone incorporates al 1 work from the main deck down to the first platform at the aft end of the ship, which is comprised of the equipment module and launcher installation. The second zone was the interface with the remainder of the ship and focused on the electronic spaces being modified.

Fabrication, outfitting, 'and installation of the Tomahawk equipment module, Zone 1, once again offers opportunity to examine the complete on-unit, on-block, onboard outfitting cycle exemplifying new construction. The process of reviewing drawings and involving trade -- and technical personnel to determine a common build strategy resulting in the issue of a work package instruction, was continued. On-block outfitting of the module was completed, along with phase one and two testing, and ready for installation when the ship arrived. Other. on-unit components were al so completed and staged for installation. After shipboard site preparation is completed, the module and new *out*-fitting components can be installed, tested, and turned over to the ship within the four-month time frame allotted.

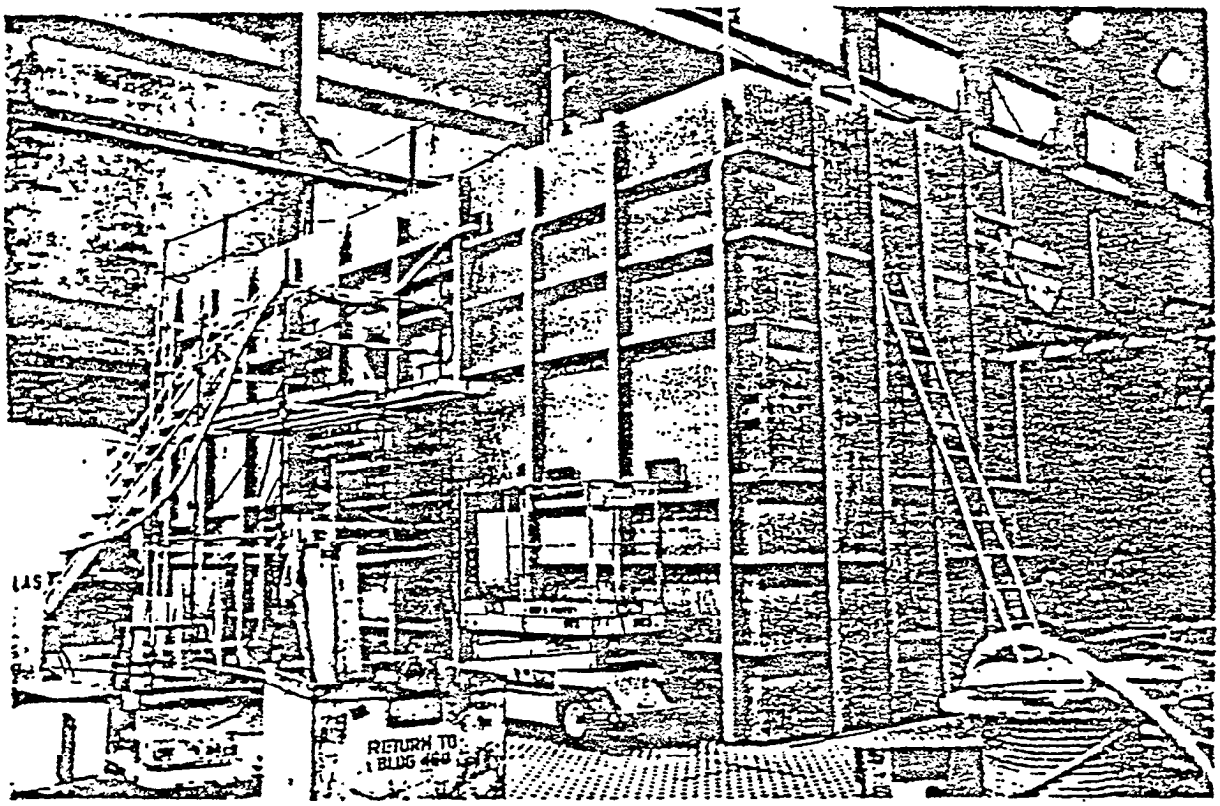


Figure 13
USS Arkansas Tomahawk module in construction.
Structural related outfitting requirements are incorporated.

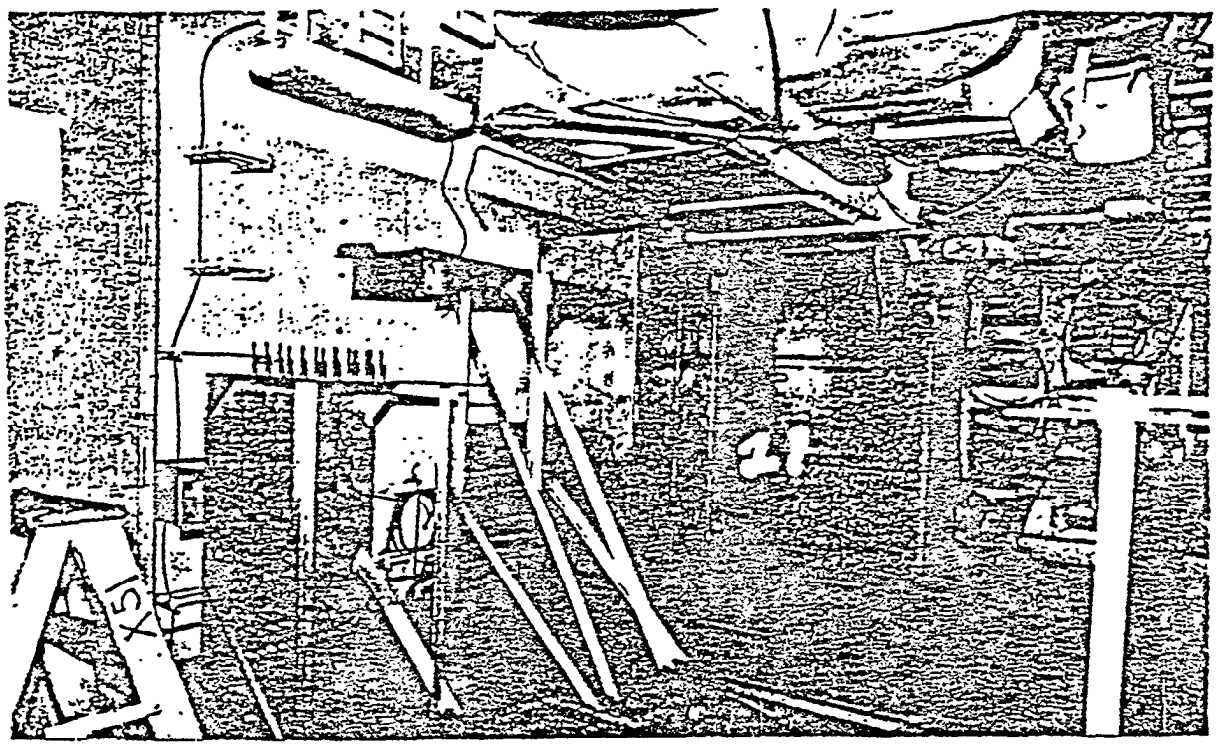


Figure 14
On-block outfitting of USS Arkansas module allowed for equipment testing ready for installation at ship's arrival.

The "spread out" nature of Zone 2 is typical of overhaul/repair work normally accomplished by the shipyard. In order to deal with this situation, Zone 2 was divided into subzones to be able to concentrate on each compartment *as* separate but interrelated products. Since work in these dispersed compartments was limited to installation of peripheral electronic equipment to support the Tomahawk module, composites were not prepared for these subzones. The use of compartment cards was introduced as a method of packaging work for each of the compartments. These cards list al 1 equipment and material requirements, material source or location, and sequencing information to be used in conjuction with the work package instruction.

COMPARTMENT MATERIAL SUMMARY CARD

CARD NO	SHEET	COMPARTMENT NO	DESCRIPTION
01-120-0-C	1 OF 3	01-120-0-C	COMBAT INFORMATION CENTER
SHIP NO. CGN 41	SHIP NAME USS ARKANSAS	AREA NO	LOCATION 01-120-0-C

DWG - WORK ORDER - MATERIAL DESCRIPTION	NAME PLATE	MATERIAL ORDERED	MATERIAL RECD	TYPE	NSN NO	MATERIAL SOURCE	QTY.	MATERIAL STATUS
1 405-4735807/30041-72191-694								
2 OPERATOR INTERACTIVE DIS TERM				O.I.D.T.	EX9-MODO	GFE	5	
3 GRAPHICS CONTROL CENTER				HCU	EX7MODO	GFE	1	
4 CABLE -- ORDERED ON TOMAHAWK COMPUTER	& EQUIP	ROOM CARD						
5 401-4735811/30041-72191-678								
6 COOLING FAIL ALARM PANEL						RAYTHEON	1	
7 SWITCH SNAP 15R2C4A-2						RAYTHEON	2	
8								
9								
10 401-4735824/30041-72191-680								
11 ALARM SWITCHBOARD IC/SM-4						RAYTHEON	1	
12 INTRUSION ALARM RELAY PANEL						RAYTHEON	1	
13 RESISTOR 6.8Ω 2W						RAYTHEON	11	
14 DOOR OPER SWITCH TYPE S-193A						RAYTHEON	3	
15 NAMEPLATES					ALARM SWITCHBOARD	RAYTHEON	4	
16 CABLE DSCU-3					7831[illegible]	PSNS	15	
17 CABLE MSCU-7					926145-00-110-2502	PSNS	50	
18 CABLE TTSU-1 1/2					926145-00-110-2375	PSNS	130	
19								
20								
21 401-4735821/30041-72191-682								
22 SWITCHBOX 20CKT				A-19A	FRGS 6201-74093	JML 41281236	1	
23 SELECTOR SWITCH 16 POS				A-26A	1 -74295	41281235	4	
24 HANDSET						41281237	4	
25 TERMINAL BOX - 60 T						41281241	1	
26 HOLDER HANDSET					S6201-74465	41281238	4	

Figure 15
Compartment card used to interface material requirements in various compartments.

CASE NO. 3: SUBMARINE TANK REPAIR

Repair of submarine tanks presents the opportunity to apply zone logic to a work process that usually does not involve installation of new equipment. The evolution of tank repair work during a typical submarine overhaul includes the opening, sandblasting or cleaning, painting, repair of damage, testing, and closing of as many as 50 tanks. The full extent of work necessary is not known until these tanks are available for inspection, which eliminates the use of the on-unit and on-block concepts of outfit planning. However, through the analysis of the typical repair cycle, identification and coordination of common onboard work processes can be accomplished.

By taking advantage of the input from production, design, planning and estimating, supply, test engineering, and scheduling the sequencing of work achieved which provides for the proper resources being at the right place at the designated time. Through this group approach, the task resultant of sequencing tank repairs is:

- Identification of repairs early in the overhaul period
- Avoiding trade interference
- Minimizing rework
- Reducing duration of the tank repair process

It is being demonstrated that through the communication and cooperation of the Outfit Planning Group, the efficiency of the submarine tank repair process is improving and will culminate in a much improved standard approach which can be applied to any submarine.

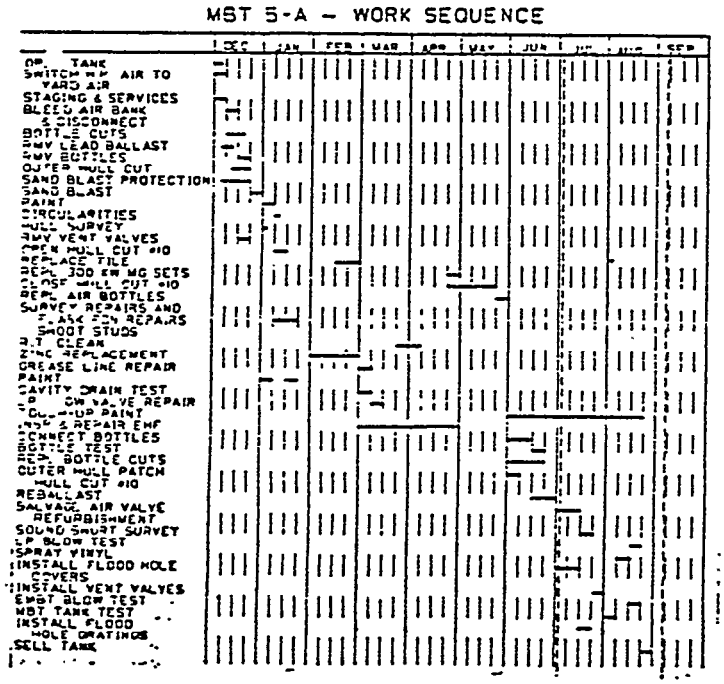


Figure 16
Bar chart used to coordinate work within submarine tank.
A similar bar chart sequences all tanks to be repaired.

CASE NO.4: USS LONG BEACH (CGN 9)

The selected restrictive avail ability of the cruiser USS Long Beach presented a new challenge to Puget Sound Naval Shipyard's outfit planning experiment. With less than two months between receipt of off-station prepared systems drawings and arrival of the ship to begin installation of Tomahawk systems, the Long Beach Outfit Planning Group was faced with developing an overhaul strategy within a very short time frame. Based on the experiences of the USS Ranger and USS Arkansas efforts, the Long Beach Outfitting Planning Group recognized that the shipyard was not yet ready to develop a full Tomahawk overhaul strategy within the extremely limited preplanning window given. However, with the attitude that zone logic could be still applied, even if only to a small portion of the project, the results would be of beneficial.

The group's efforts quickly focused on the crew living area directly below the Tomahawk launcher locations. Because of considerable structural changes required to support the launchers, all of the systems mounted to the overhead needed to be either replaced or modified. Because of the heavy congestion in this area, a composite was prepared by the design agent to aid the design effort.

In order to provide a viable sequence of onboard work, the group enhanced the use of existing composite drawings by the following process.

- Developed a structural panel drawing (SPD) depicting the new structural configuration of the crew living space overhead at 1 -1/2" = 1'-0" scale.

- Gave a reproducable copy of the SPD to each trade that had work to accomplish in this area, to delineate their particular system on the drawing based on systems drawing provided. The trades also identified their prefabrication requirements.

- The marked SPD's were collected and combined into a single overlay composite to accurately resolve interferences. Zone logic was used to identify construction and installation advantages.

- The resolved composite was then used by all trades to coordinate hanger locations, which allowed the hangers to be installed without having system components available.

With the installation sequence thus developed and agreed to, the composite became the tool by which the zone manager could control the outfitting installation onboard.

CASE NO. 5: USS TEXAS (CGN 39)

The complex overhaul of the cruiser USS Texas is furnishing the shipyards outfit planning experiment with the opportunity to expand the work package instruction process into a zone prefab work package related to a master bill of erection sequence. Building on the experiences of the previous outfit planning projects, the Texas Outfit Planning Group is making significant inroads on the way technical information is to be given to production personnel.

This project involves the 'installation of Tomahawk missile capability similar in scope, but different in detail from the USS Arkansas project. Attention is being placed on the prefabrication and outfitting of 46'x20'xl9' 125-ton magazine/launcher module, and reconfiguration of two electronic control rooms. The electronic control room portion is designated as Zone 2, and will use a compartment card and composite drawing

combination to provide the basic tools for work analysis, sequencing, and instruction. The procedures used will be similar to those previously discussed as enhanced by the appropriate findings of the following process.

Major emphasis for the USS Texas project is on the magazine/launcher module, Zone 1, to deliver a more comprehensive work instruction to the mechanic in the form of a zone prefab work *package. This document will consist of numerous individual work instructions prepared from a complete CAD model of the module being built using a sequenced panel method.

The CAD model is being developed from system drawings provided by another design agent, and by using the layering capability of the CAD, each identified system is easily accessible individually or collectively. Systems input into the layered CAD files is being accomplished through a joint effort between design and production personnel. Where system rerouting may take advantage of using common hangers *or* improve manufacturing methods, hand layouts are being prepared by design personnel for review by the Outfit Planning Group. Once the rerouting is firm, production personnel will locate the required hangers. This new data is then entered into the CAD to form an optimized CAD composite from which the graphic portion of the work instruction is developed.

The work package instruction is being enhanced by relating work to a sequenced panel erection process whereby each structural surface that makes up the zone is individually developed to reflect not only the structural members but also the outfitting components. These components are further identified as prefabricated pieces and tracked through the ordering, fabrication, and installation processes. With each piece being identified and tracked, control of the erection sequence is more manageable. This method provides for tracking of a piece from the original drawing, to 1ocating the material required, where it is staged, when it is to be fabricated, which panel it is a part of, when it is to be installed, and how it is to be sequenced into the overhaul strategy. The work instructions are scheduled and sequenced in the zone prefab work package to reflect similar work processes and common manufacturing methods.

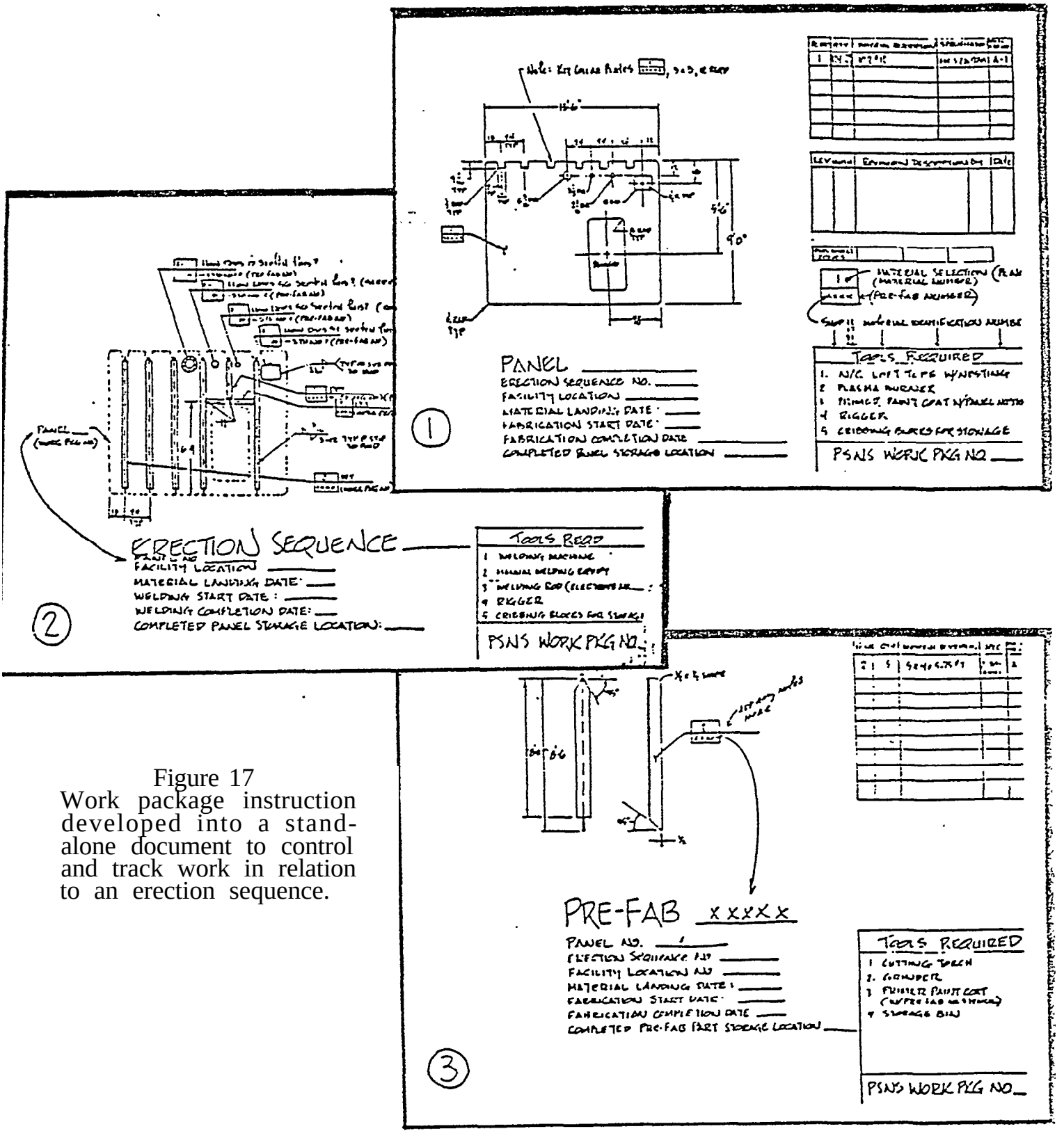


Figure 17
Work package instruction developed into a stand-alone document to control and track work in relation to an erection sequence.

CONCLUSION

Adoption of zone logic concepts, developed for new construction projects, into the naval ship overhaul /repair process is continually proving its benefits, Unlike new construction, overhaul /repair work adds the necessity of dealing with existing entities that must be accounted for when planning new work. This results in gathering definitive data reflecting existing conditions installed by traditional system by system thinking, and integrating into it new work planned with zone logic concepts. Because of this added complexity factor and the potential. organizational impact of zone logic, it was determined that an evolutionary process of small projects would best serve Puget Sound Naval Shipyard ' s venture.

The key factor to the continuing success of outfit planning at the shipyard is the establishment of interdepartmental groups to examine', develop, apply, and evaluate zone logic concepts for the various overhaul projects. By concentrating knowledgeable shipyard resources into one group and providing the forum for departmental interaction, levels of mutual respect and trust are reached which allows the channels of communication to open, and helps all members to understand how each is interfaced in the total ship overhaul process.

A large portion of the outfit planning projects have been aimed at prefabrication and outfitting of large modules being added to the ships. These types of projects represent a small portion of a normal ship overhaul while the majority of overhaul /repair work takes place within the existing hull. These hull modules have been emphasized during these early stages of the outfit planning experiment because they represent a common 1 ink between new construction and overhaul of existing ships, which provides the opportunity to become familiar with zone logic ideas. However, because of the mix of projects undertaken thus far, it is evident that the majority of future routine overhaul/ repair work will concentrate on the coordinated sequence of on-unit and onboard outfitting concepts.

By taking advantage of applying the shipyard's knowledgeable resources to analyzing work requirements, developing an overhaul strategy, and accomplishing as much work as possible before the ship arrives, a number of actual and potential benefits are being realized.

- Identifying and coordinating common trade requirements to reduce or eliminated accomplishing similar work in the same area at different times.
- Performing component fabrication and assembly under better, safer conditions in the shop rather than onboard the ship where competition for space hinders productive efforts.
- Work sequencing coordination which minimizes rework.
- Dedicated material staging areas and tracking methods to have components avail able when and where they are needed.
- Introduction of advanced technology procedures such as the use of photogrammetry and computer aided design.

Perhaps the most significant benefits realized are the involvement of the Production Department during the planning phase, and the development of the work package instruction. By partici - pating in planning shipchecks and interacting with design personnel, the Production Department gains an improved understanding of the overall task requirements. Through this process the

Planning Department can provide improved instructions to support production methods. This interaction promotes a technical /trade teamwork approach to resolving problems on an equal basis.

In its development from the USS Ranger project to the USS Texas project, the work package instruction has become a powerful tool in using zone logic. The work package has evolved into a document that not only stands alone for the mechanic to accomplish his work but it has become the tool by which other related shipyard functions can be tracked. Items such as. manning, scheduling, material, budget, progressing, historical data, and quality assurance can now have a common vehicle through which overhaul projects can be managed to reflect actual work requirements.

Puget Sound Naval Shipyard's experiences with outfit planning have both been positive and progressive. The change in thinking of identifying and accomplishing work by application of zone logic has met resistance with those who have "grown up" with the traditional systems approach; however, as each project has progressed, response has become much more favorable as the benefits are recognized. Step by step, as more people accept and participate in this logic change, more ideas are being injected to improve the shipyard's method of doing business.

PIPE FABRICATION TO SUPPORT MODERN SHIP CONSTRUCTION METHODOLOGY

The Implementation of an Integrated Fabrication Control Philosophy in a Modernized Shipyard Pipe Shop

16 August, 1985

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Abstract

1.0 Introduction

- 1.1 Maritime Industry Perspective
- 1.2 Background

2.0 Fundamental Concepts of Modern Pipe Fabrication

3.0 Facility Modernization

- 3.1 Economic Analysis / Justification
- 3.2 Industry Survey
- 3.3 Detail Project Design

4.0 Manufacturing Control Philosophy

- 4.1 Introduction
- 4.2 Group Technology With Respect to Pipe Fabrication
- 4.3 Classification of Pipe Pieces
- 4.4 Shop Work Center Definition / Duration Assessment
- 4.5 Labor Standard Development
- 4.6 Detail Shop Plannning / Scheduling
- 4.7 Cost Collection / Performance Measurement

5.0 Conclusions

- 5.1 Summary
- 5.2 Assessment of Improvements
- 5.3 Anticipated Programs
- 5.4 Human Factors

ABSTRACT

In October of 1983, National Steel and Shipbuilding Company, as part of a yard-wide advanced technology implementation program, initiated a project to modernize its existing pipe fabrication operation. The modernization included facility enhancements, equipment aquisitions and involved the implementation of an integrated manufacturing control philosophy beginning in design and employing principles of group technology with respect to pipe fabrication.

The paper summarizes the efforts associated with the pipe fabrication modernization project by tracing the facility enhancement from the initial feasibility studies to detailed shop layout and by describing the operating procedures currently being implemented in the pipe shop to support an integrated manufacturing control philosophy An assessment of the favorable impact on productivity of the new facility and methodology is discussed as well as several facility and technology enhancements identified as appropriate steps to further improvement in pipe fabrication productivity.

1.0 INTRODUCTION

Maritime Industry Perspective

Worldwide, the shipbuilding industry is suffering from an imbalance in the supply and demand of most forms of sea-going tonnage. Current overcapacity conditions, as well as the present world economy have produced an extremely soft demand for new construction, conversion and repair projects. In this market environment, the ability to seriously compete for available work requires that shipyards maximize the quality of the product they produce while minimizing building cycles and total costs. While lower labor rates are a significant factor in minimizing costs, shipyards must adopt long-range strategies that incorporate more efficient, advanced ship construction methodologies. as employed by leading Japanese shipyards today.

Domestically, high labor rates and less technologically advanced construction techniques have made American shipyards non-competetive on a world-wide basis. Additionally, the elimination of construction differential subsidies has discouraged domestic operators from considering domestic yards for new building projects. The implementation of advanced ship construction technology in domestic shipyards is required for their commercial survival. In several yards, this implementation has begun, with favorable results reported thus far.

Background

In the spring of 1983 National Steel and Shipbuilding Company (NASSCO) initiated a yard-wide advanced technology implementation program encompassing all facets of ship construction including planning, materials procurement, engineering, information systems and production. Part of this implementation program involved the creation of several projects addressing key functions in the shipbuilding process identified as potential sources of productivity improvement. The projects, identified as "Group Technology Implementation Projects", were generally organized with a project leader who had the responsibility of and authority to change existing systems or procedures addressed in the specific project. Supplying research and technical support for the project was a staff assistant with consultation provided by one of several consultants from Ishikawajima-Harima Heavy Industries (IHI) Marine Technology Group.

Group Technology Implementation Project #11: "Pipe Shop Layout and Product Flow" was initiated in October of 1983.. The purpose of the project was to modernize the existing pipe fabrication operation at NASSCO through the application of facility enhancements and equipment aquisitions to increase the level of manufacturing technology in the shop and to provide an integrated manufacturing control philosophy beginning in design and incorporating all areas of pipe fabrication control.

This paper is intended to provide a detailed account of the development and implementation of modern pipe fabrication at NASSCO. Included is a complete discussion of the facility modernization from initial economic feasibility studies through detailed facility design. The group technology-oriented manufacturing control philosophy is described with discussion including classification, labor standard development, detailed shop planning/scheduling, cost collection and performance measurement. Human factors are addressed and projected productivity improvements discussed. Finally, several facility and technology enhancements are identified as appropriate steps to further improvements in the manufacturing operation.

2.0 FUNDAMENTAL CONCEPTS OF MODERN PIPE FABRICATION

In order to provide a complete discussion of modern pipe fabrication at NASSCO it is necessary to identify several concepts that reflect efficient manufacturing of pipe pieces to support modern ship construction methodology. These concepts formed the basic objectives of the pipe fabrication modernization project at NASSCO and are described below:

Objective 1: Dictate the design of the spools to conform to facility constraints and optimum fabrication techniques.

A pipe spool is an assembly of pipe, flanges and fittings that is defined as part of a particular piping system. Pipe spools are assembled in the pipe shop in order to minimize the amount of pipe fitting and welding required during subsequent construction stages (on-unit, on-block, on-board). This objective addresses the need for pipe spools to be designed for producibility at the lowest practical cost. In order to satisfy this need, a great deal of production-oriented knowledge must be reflected in the design of the pipe spool. Included in this knowledge is an understanding of machine and facility constraints, fabrication methods and manufacturing sequences.

While this objective is not addressed in detail here, it should be noted that several efforts are currently underway at NASSCO to provide for effective transfer of current production knowledge into the design process. The efforts include a production-oriented design manual developed jointly

between Engineering and Pipe Shop personnel, seminars in pipe fabrication for those directly involved in spool design and continuous liason interaction to resolve problems encountered day to day.

Objective 2: Gain organizational control over the total manufacturing process.

In the case of pipe fabrication to support ship construction, manufacturing is not complete until all operations, including cleaning and coating of the pipe spool, are completed. Additionally,' pipe spools must be grouped or "packaged" to support the work breakdown structure of subsequent stages.

Effective manufacturing control and thus lower total cost for the shipyard is achieved when all manufacturing operations are responsible to the organization responsible for manufacturing. This may seem obvious but is not always easy to implement given existing facilities and organizational structures. Additionally, the operations should be adjacent to one another to gain the benefits of reduced material handling.

Objective 3: Increase the level of fabrication technology in the pipe shop.

Advances in machine technology have a positive effect on productivity with respect to operation

process times. Automated material handling technology as well as rational plant layout reduces non-process time and also has a positive effect on productivity.

Objective 4: Simplify and streamline product flow and process sequence.

From an industrial engineering perspective, the simplification of the manufacturing process through effective plant layout, operation resequencing and the definition of process flow lanes results in an efficient, streamlined product flow. This translates into reduced operating costs, better control of the work flow and a framework in which continuing improvements can be made.

Objective 5: Develop consistent methods to plan, schedule, route, collect cost and compute performance with respect to the manufacturing processes involved.

An integrated manufacturing control philosophy incorporating group technology techniques for controlling the work flow through the shop is necessary to effectively manage the the manufacturing operation. The philosophy must reflect current facilities and capabilities and provide for explicit means to project future work, accomplish scheduled work, record finished work and compute the necessary productivity parameters used in the management of the shop.

3.0 FACILITY MODERNIZATION

Economic Analysis / Justification

The design of a facility to support modern pipe fabrication was accomplished in three basic stages. Stage One consisted of an analysis of the economic feasibility of the facility modernization based on projected throughput and three modernization alternatives. The results of this analysis led to a subsequent justification analysis addressing the most favorable of the alternatives. Stage Two consisted of a survey of selected domestic and foreign pipe fabrication operations. Stage Three was the development of the detailed design of the facility including detailed shop layout, equipment specification and construction planning.

The feasibility study addressed three facility modernization alternatives representing varying levels of productivity improvement at varying levels of investment. The first alternative was an upgrade of the existing pipe shop consisting of a rearrangement of equipment to support improved material flow and selected equipment aquisitions to upgrade the current manufacturing technology in the shop. Since the size of the existing shop was fixed (approximately 28000 square feet), this alternative dictated that the cleaning, painting and packaging (palletizing) of pipe spools would remain physically and organizationally separated from the prior fabrication operations.

The second alternative involved the upgrade of the existing pipe shop, the aquisition of an adjacent building previously used for foundry operations and the dedication of all the area surrounding the pipe shop and foundry to pipe fabrication. This alternative represented an increase of approximately 25000 square feet and allowed for the centralization of all pipe spool manufacturing operations both physically and organizationally. The following operations were included in this design:

- in-process storage, pipe and fittings
- external abrasive cleaning of pipe
- cutting to length of pipe
- cold-bending of pipe
- fitting
- welding
- chemical cleaning
- galvanizing
- painting
- palletizing (packaging)

Additionally, equipment was identified that would upgrade current technology in the shop.

The third alternative consisted of the construction of a new pipe fabrication facility based on a shop layout designed to optimize product flow by strategic location of work centers and installation of state-of-the-art material handling systems. New equipment was identified as part of this alternative.

Based on the results of the feasibility study, alternative number two was determined to be the most cost-effective of the three. A detailed cost/benefit analysis of this alternative was carried out and in the spring of 1984 the funding for the modernization of the pipe fabrication facilities at NASSCO based on alternative number two was approved.

Industry Survey

An industry survey was conducted during the first quarter of 1984 to assess various pipe fabrication operations in terms of shop layout, product flow, material handling, current equipment technology, manufacturing control procedures and the product mix normally processed through the individual shops. Four domestic and two foreign pipe fabrication operations were visited. They were:

- Pipe shop, Avondale Shipyards, Inc., New Orleans, Louisiana
- International Piping Systems, Ltd., Port Allen, Louisiana
- Pipe Shop, Ingalls Shipbuilding, Litton Industries, Pascagola, Mississippi
- Texas Pipe Bending Company, Houston, Texas
- Pipe fabrication works, Aioi Shipyard, IHI Company, Ltd., Aioi, Japan
- Pipe shop, Kure Shipyard, IHI Company, Ltd., Kure, Japan

A rigorous analysis of these operations helped to formulate the design criteria used to develop the detailed shop layout and equipment specifications of the modernization. Also instrumental in the conceptual development of both the facility and the philosophy were several reports published by the National Shipbuilding Research Program. (1,2)

Detail Facility Design

The pipe fabrication facility to support modern ship construction methodology at NASSCO encompasses an area of approximately 53000 square feet. In the facility, the manufacturing of pipe spools proceeds from in-process raw material storage of pipe and fittings to packaging (palletization) of completed, painted pipe spools. The facility is divided into five functional areas, each area corresponding to one of the five major manufacturing operations defined for a pipe spool. A definition of the area utilization is given in Table I and a layout of the facility is given in Figure I.

TABLE I
Area Utilization

Area	Square Feet	Percent
Preparation	6500	12 %
Bending	5700	11 %
Assembly	15000	28 %
Treatment	16000	30 %
Palletize	7000	13 %
Support	2800	6 %

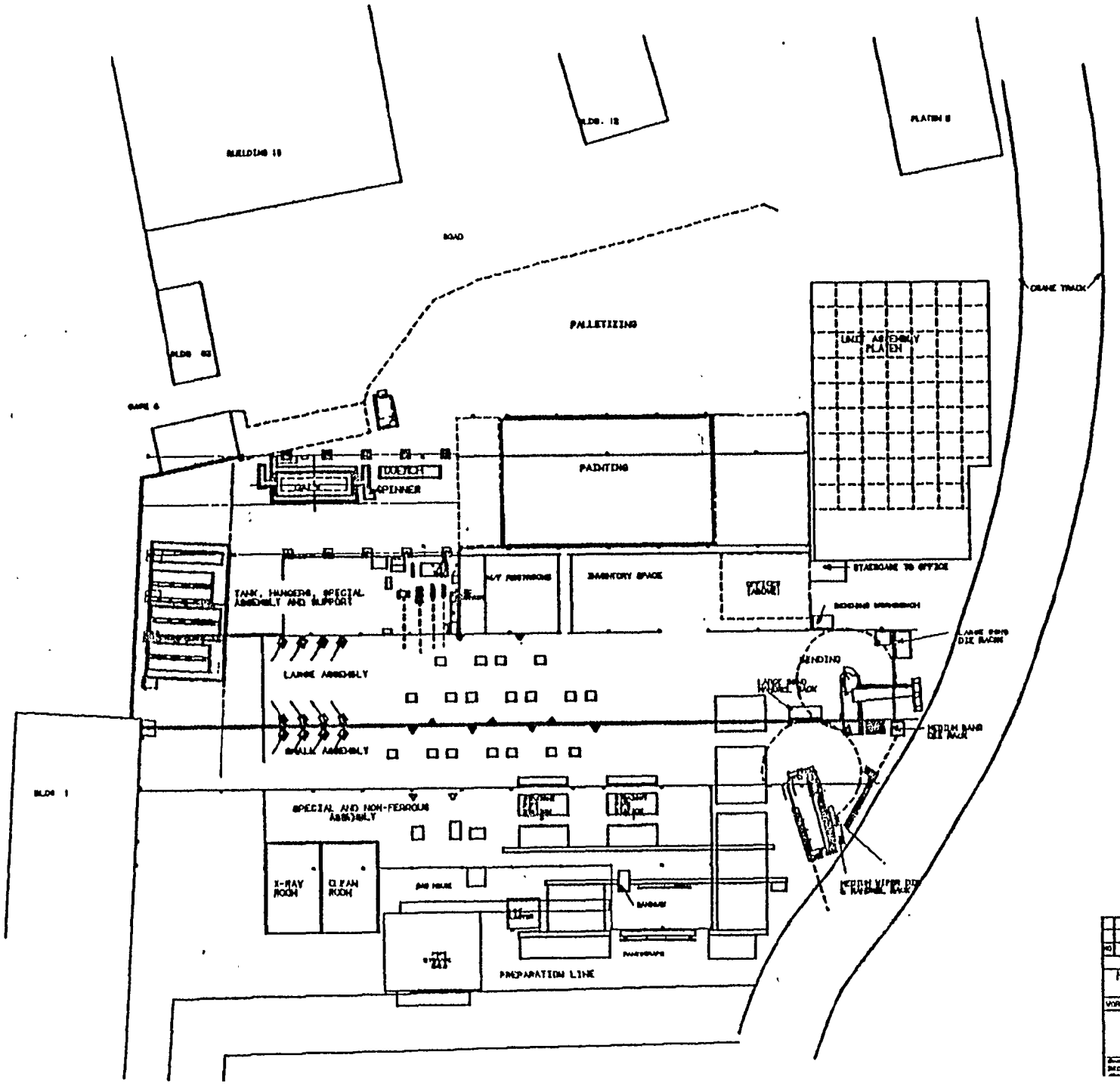


FIGURE I
Pipe Shop Layout

Preparation Area

The preparation area consists of equipment and machinery used to store, clean, cut and convey raw pipe stock in support of subsequent bending, assembly or treatment operations. The configuration of the raw material is well suited for automated material handling applications and is exploited in the preparation area. A steel structure capable of storing over twelve thousand feet of raw pipe stock from 2"-12" in diameter and 20-24 feet in length in a series of horizontal shelves allows for the rapid withdrawal of pipe by material, schedule and diameter. Pipe withdrawn from the storage structure (silo) is then transported via axial conveyor to a shotblasting machine where rust, mill scale and preservative are mechanically removed from the exterior of ferrous pipe. After processing through the shotblast machine, pipe is transported via axial conveyor to the cutting center where the raw pipe stock is cut to the design lengths specified for each pipe spool. The cutting is performed on a vertical bandsaw or contour cutting machine. After cutting, the "pre-cut" pipe pieces are then axially and laterally transported to three buffer tables where they are staged for bending or assembly. The entire material handling system is designed for automatic operation on pipes up to 12" in diameter. For larger diameter pipe, semi-automatic processing through the preparation area is possible. The preparation area is in the final phase of installation and is scheduled for production early in 1986.

Pre-cutting pipe prior to bending or assembly represents a major change in the traditional fabrication methodology employed in the pipe shop. The implementation of pre-cutting as the first manufacturing process in the shop is anticipated to yield substantial productivity improvement in the overall pipe spool manufacturing operation.

Bending Area

Adjacent to and downstream of the preparation area is the bending area where pipe requiring bending is processed on one of three sizes of rotary-type hydraulic cold bending machines. The machines are capable of bending pipe up to 12" in diameter and are grouped in the following way:

- o large bending - 6"-12"
- o medium bending - 2-l/2"-4"
- o small bending - up to 2-l/2".

Pre-cut pipe pieces requiring bending are staged in the bending area on buffer tables connected to the preparation line. To support the manual loading and unloading of pipe onto and off of the bending machines, the existing overhead bridge cranes of the old pipe shop were utilized. Crane rail extension was necessary to provide complete support for medium-sized bending. After bending, the overhead bridge cranes transport the pipe pieces into the assembly area where they are staged with the necessary material needed to complete the pipe spool.

Assembly Area

Occupying the old pipe shop building and arranged in four basic process lanes is the assembly area of the pipe shop. In the assembly area raw pipe stock, flanges and fittings are fitted and welded to form an assembly of components referred to as a pipe spool. The spool is fabricated according to design information provided on supplementary instruction sheets or "spool sheets".

At the beginning of the assembly area is a material staging zone where the pre-cut and/or bent pipe pieces are kitted with the necessary fittings and/or flanges that correspond to a particular pipe spool. From this zone, material is delivered to individual work benches at the discretion of the assembly area supervision.

The process lanes defined in the assembly area are as follows:

- o straight pipe spool assembly
- 0 large complex pipe spool assembly
- o small complex pipe spool assembly
- o special and support assembly

The straight pipe spool assembly lane is integrated with the material handling system of the preparation line. The lane is intended to process straight pieces of pipe with sleeves, couplings or flanges on one or both ends in a semi-automatic manner. All material transport will be by way of axial conveyors and inclined lateral transfer tables. Fitting and welding stations are designed such that pipe is deliv-

ered to them on one of the inclined transfer tables. The fitting station allows for leveled, jig-supported fitting of sleeves, couplings and flanges on one or both ends of straight pipe while 'the welding station, supported by powered rollers and an overhead trolley carrying the necessary welding equipment, allows for semi-automatic welding of several welding processes. The straight pipe processing line will come into production with the completion of the preparation area early in 1986.

The design of the straight pipe lane followed a prototype approach where existing equipment and components were modified to-suit defined processing requirements. This prototype will be used to generate the technical specifications for a more sophisticated semi-automatic or automatic processing station to be incorporated into the straight pipe lane at a later date.

The complex pipe spool assembly lanes support the manual fitting and welding operations that are necessary on two and three dimensional pipe spools. Standard fitting benches are installed in each lane with a material delivery aisle down the center of the large complex lane and down the side of the small complex lane. The large complex pipe spool lane corresponds to the large bay of the assembly area and is intended to process pipe spools 6" in diameter and above. The small complex pipe spool lane corresponds to the small bay of the assembly area and is intended to process pipe spools 4" in diameter and below.

After fitting at one of the fabrication work benches in the assembly area, the pipe spool is transported to the "weld-out" zone of the assembly area where it is production welded on positioning machines. It should be noted that two welding stations are installed in the fitting area to support more efficient welding of straight sections of complex spools. The stations are referred to as "roll-out" stations.

After the spool has been welded, it is staged for processing through the treatment area.

Treatment Area

The treatment area contains facilities for chemical cleaning, hot-dip galvanizing and painting pipe spools. Installed in this area are eight tanks containing chemical cleaning solutions, a gas-fired molten zinc kettle and an enclosed painting cabin. Fabricated and welded pipe spools are processed through the area by a system of overhead bridge and gantry cranes and by wheeled painting racks used in the paint cabin.

The constraints imposed by existing structures and the overall configuration of the treatment area dictated the need for a unique material handling system design. The two overhead bridge crane rails for the large and small assembly bays were extended to span the entire treatment staging area. The cranes serve as the primary method of transport for spools completed in the assembly area. Operating at approximately right angles to and Just below the rails of the overhead

bridge cranes is a half-gantry crane with a column-supported rail against the side opposite the assembly area and a ground-level rail adjacent to the assembly area. The half-gantry is used to process batches of pipe spools requiring similar treatment processes through the chemical cleaning tanks. After chemical cleaning, spools are staged in one of two adjacent bays depending on the type of coating required. The bays run at approximately right angles to the half-gantry rails and are supported by side-by-side bridge cranes which run on rails just above the half-gantry crane. In the first bay, pipe spools requiring hot-dip galvanizing are processed through a galvanizing kettle and water quench tank and then staged for painting or palletizing. The second bay is used as a staging area for spools requiring painting only.

Chemical cleaning is performed on ferrous piping to provide the necessary surface preparation for galvanizing or painting. in the past, only pipes requiring galvanizing were processed through the cleaning tanks. Pipes requiring painting were transported to another area in the shipyard for manual shotblasting to establish the correct surface preparation. Chemical cleaning of all ferrous piping prior to galvanizing or painting is a significant improvement in the processing of completed pipe spools and is anticipated to yield substantial improvement in the productivity of the manufacturing operation.

To provide the ability to paint pipe spools at the pipe shop, a 88'-0 by 52'-0 ventilated paint cabin was installed. The cabin is divided into four quadrants designed to provide for painting and drying of several different paint systems simultaneously. There are two painting areas and two drying areas, each of which is supported by a separate filtering and ventilation system. Material handling in the paint cabin is accomplished by push carts loaded with racks designed for pipe spool painting.

Palletizing Area

Completed pipe spools are packaged for subsequent installation in the palletizing area. The area is divided into 20 marked locations where packages of pipe spools are maintained. The pipe spools are stored in steel tubs or "pallets" approximately 12 feet long by 6 feet wide by 2 feet high. The configuration of the pallets allows for stacking up to 4 high in each marked location making the total number of possible packages to be maintained in this area 80.

Recent operations have indicated that this area is not sufficient to adequately handle both the kitting and storage operations. High throughput requirements of the pipe shop to meet production schedules has caused severe overcrowding of the area and consequently reduced operating efficiency. Another area in the shipyard located approximately 100 yards away is currently being used to kit and store completed packages until they are needed for installation.

Unit Assembly Area

In support of the stage of construction philosophy utilized in modern ship construction technology, a unit assembly platen was installed as part of the pipe fabrication facility modernization project. The platen, fabricated from surplus steel hatch covers removed from a recent ship conversion contract, is approximately 8000 square feet in area and is utilized for the construction of outfitting units and pipe racks. To support this type of construction, the unit assembly area is fitted with several jib cranes, a complete list of the services required for fitting, burning and welding and an inventory area used to supply small parts such as nuts, bolts, pipe hangers and gaskets.

Miscellaneous Facility Enhancements

While the majority of the facility enchancement effort was directed at the five functional areas previously identified, several other improvements were also carried out. They were the following:

Installation of an inventory space for in-process matial. The inventory space is located adjacent to the assembly staging area to facilitate kitting of material with pre-cut pipe pieces processed on the automated pipe processing line. Also located in the inventory space is a tool room and weld rod storage area.

Installation of restroom facilities including lockers and shower facilities. The restrooms were installed to replace existing restroom facilities and represent a significant upgrade in the habitability of the pipe shop.

Installation of a second-floor office space. The office space was installed to provide a centralized location for the administration and management of the five functional areas in the shop. Through this office, the manufacturing of pipe spools from initial material withdrawal from the yard warehouse to delivery of fabricated, coated pipe spools packaged by installation requirements to the subsequent stages of construction is coordinated. All supervisory and clerical personnel associated with the manufacture of pipe spools are located in this office.

4.0 MANUFACTURING CONTROL PHILOSOPHY

Introduction

Much emphasis has been placed on the installation of state-of-the-art equipment and facilities to improve the competitive position of shipyards and specifically shipyard outfitting shops. While modern equipment and material-handling techniques do increase productivity, substantial improvement can also be achieved through the effective application of manufacturing control methodologies, especially those that employ principles of group technology. This is particularly true in the case of pipe shops where group technology principles identifying the "sameness" of parts can be readily applied to the fabrication of pipe pieces.

Concurrent with the design and installation of the new pipe fabrication facilities at NASSCO was. the design and development of a group technology-oriented manufacturing philosophy. The philosophy identified integrated techniques for scheduling and routing work through the shop, projecting manpower requirements, collecting fabrication costs and computing performance parameters in a way that could be meaningfully applied to the management of the manufacturing effort. This section describes that philosophy by discussing the methods currently being implemented in the pipe shop at NASSCO. Before going into the details of the implementation, however, it is necessary to present a brief discussion of group technology manufacturing and how it relates to pipe fabrication.

Group Technology With Respect to Pipe Fabrication

The origin of group technology (GT) is somewhat obscure but researchers on the subject generally agree that S. P. Mitrofanov of the USSR was the originator of the technique. It is also agreed that Mitrofanov's developments were based on work originally done by A. P. Sokolovski, also of the USSR. In the 1930s Sokolovski suggested that, in general, standardized processes and manufacturing techniques should be used on parts of similar configuration and features. A translation of a more applicable definition is provided by Mitrofanov:

> GT is a technique for manufacturing small to medium sized batches of parts of similar process, of somewhat dissimilar materials, geometry and size, which are produced in a committed small cell of machines which have been grouped together physically, specifically tooled, and scheduled as a unit. (3)

Using this definition as a basis, group technology manufacturing with respect to pipe fabrication can be defined as the identification of the "sameness" or commonality of parts, specifically pipe spools, by virtue of those attributes which define the specific manufacturing processes required; and subsequent grouping or classification of those like parts to maximize the efficiency of the work centers producing them. It is possible, under this definition, for work to flow in a line or series fashion, utilizing the same equip-

ment or machinery as in the preparation or treatment areas, or for work to be accomplished in a parallel, process lane fashion, as in the bending or assembly areas.

Classification of Pipe Pieces

A necessary element for the implementation of group technology manufacturing techniques is the development of a classification system by which to accurately categorize the scope of work to be processed. 'The following definition is applicable:

> A technique to organize. specific data relating to the relevant component element(s) of a business or institution in a logical and systematical hierarchy, whereby like things are brought together by virtue of their similarities, and then separated by their essential differences. (4)

To expand on this, the following principles are defined:

- All Embracing - A classification must embrace all items and be able to accept necessary new items into the defined population of items.
- Mutually Exclusive - A classification must bring like items together while excluding unlike items, using clearly defined parameters. That is, there must be one place and one place only for any one item.

- **Based on Permanent Characteristics** - A classification must be based on visible attributes or easily confirmed permanent or unchanging characteristics. Fortuitous, ambiguous and non-permanent characteristics must not be used.

- **From User's Viewpoint** - A classification should be developed from a single point of view, that of the user and not the classifier. (5)

A classification system for the manufacturing of pipe spools at NASSCO was developed using the above principles as guidelines. The system is based on five attributes of the design and manufacture of a pipe spool. The attributes are:

- material
- size (diameter)
- configuration
- assembly
- treatment

The size attribute is imbedded into the configuration and assembly attribute in order to simplify the coding of the classification system. The following is an explanation of each of the four "explicit" attributes.

The material attribute identifies from what type of material the spool is manufactured. This attribute is design or specification driven in that the material type will be determined by the shipboard piping system the pipe

spool will ultimately become a part of. The purpose of this attribute in the classification system is to define what type of processing the spool will undergo in the shop (i.e. flame versus mechanical cutting, 3-D versus 5-D cold bending, welding versus brazing). This information is utilized in the determination of shop routing, scheduling and loading.

The configuration attribute identifies cold bending requirements of a pipe spool. Cold bending in lieu of fittings is cost-effective from a fabrication standpoint. Where possible, designers are instructed to use bends as a means to change the direction of a piping system run. In the shop, this means' that the pipe spool must be scheduled and routed through one of three rotary-type hydraulic bending machines located in the bending area. These machines bend pipe from 1" to 12" in diameter. The configuration attribute defines whether bending is required and if so, which of the machines will be used.

The assembly attribute identifies the type of assembly required for the spool and also identifies the process lane in the shop where the spool will be assembled. There are two basic types of assembly: straight and complex. Straight assembly is defined as fitting and welding of flanges, sleeves, couplings and selected fittings on one or both ends of raw pipe stock in a semi-automated manner. Complex assembly is defined as any assembly requiring set-up of the spool on a workbench and lack-stands. Assembly is further broken down into large and small based on diameter where small is 1"

to 4" and large is 6" to 12". Pipe spools over 12" in diameter are regarded as special assembly. Other spools requiring unique assembly are also classified as special using this attribute. The assembly attribute is not design or specification driven but is used solely for production control in the shop.

The treatment attribute describes the treatment processes required for the spool after fabrication. These processes are dictated by the shipboard piping system and ship zone where the spool will ultimately be installed. In this respect, the treatment attribute is design-driven. The processes identified under this attribute include chemical cleaning, galvanizing and painting.' The attribute identifies the various combinations of these processes.

Coding System

The classification system is supported by a four digit numerical coding system which defines all possible values of the four pipe spool attributes. The four digit code, commonly referred to as the family number, defines ninety-three possible pipe spool families. The following is a listing of possible attribute values. Figure II summarizes this information.

Material Attribute

1 Ferrous - ASTM A-106, ASTM A-53 or any other material having characteristics that allow

it to be processed through the shop in the same manner as the above specifications.

2 Non-Ferrous - ASTM B-88 Copper Type-K, ASTM B-466, B-467 (CuNi 90-10) Alloy 706 or any other material having characteristics that allow it to be processed through the shop in the same manner as the above specifications.

3 Other - special materials not classified under 1 or 2 above. Examples include fabricated hoses and fiberglass reinforced plastic pipe.

Configuration Attribute

0 No Bending – any pipe spool not requiring bending.

1 Large Bending – pipe spools 6" to 12" requiring bending.

2 Medium Bending – pipe spools 2-l/2" to 4" requiring bending.

3 Small Bending – pipe spools 2" and below requiring bending.

Assembly Attribute

0 No Assembly - any pipe spool 1" to 12" not requiring assembly (defined here to be fitting, welding, brazing and/or bolting).

1 Large Straight – pipe spools 6" to 12" in diameter with a flange or coupling on one or both ends.

2 Small Straight – pipe spools 1" to 4" in diameter with a flange or coupling on one or both ends.

3 Large Complex – pipe spools 6" to 12" in diameter requiring manual assembly of fittings, flanges, sleeves, saddles, etc.

4 Small Complex – pipe spools 1" to 4" in diameter requiring manual assembly of fittings, flanges, sleeves, saddles, etc.

5 Special Assembly - pipe spools not falling into any of the above assembly categories due to size (greater than 12"), special assembly processes (miter cuts, *threaded ends 2-l/2" and above), special assembly sequences (weld after galvanize), testing requirements or exotic materials.

Treatment Attribute

0 No Treatment - pipe spools not requiring treatment.

1 Clean/Paint - pipe spools requiring chemical cleaning and painting at the pipe shop.

2 Clean/Galvanize/Paint - pipe spools requiring chemical cleaning, galvanizing and painting at the pipe shop.

3 Clean/Galvanize - pipe spools requiring chemical cleaning and galvanizing but by-passing painting.

4 Paint - pipe spools requiring painting at the pipe shop.

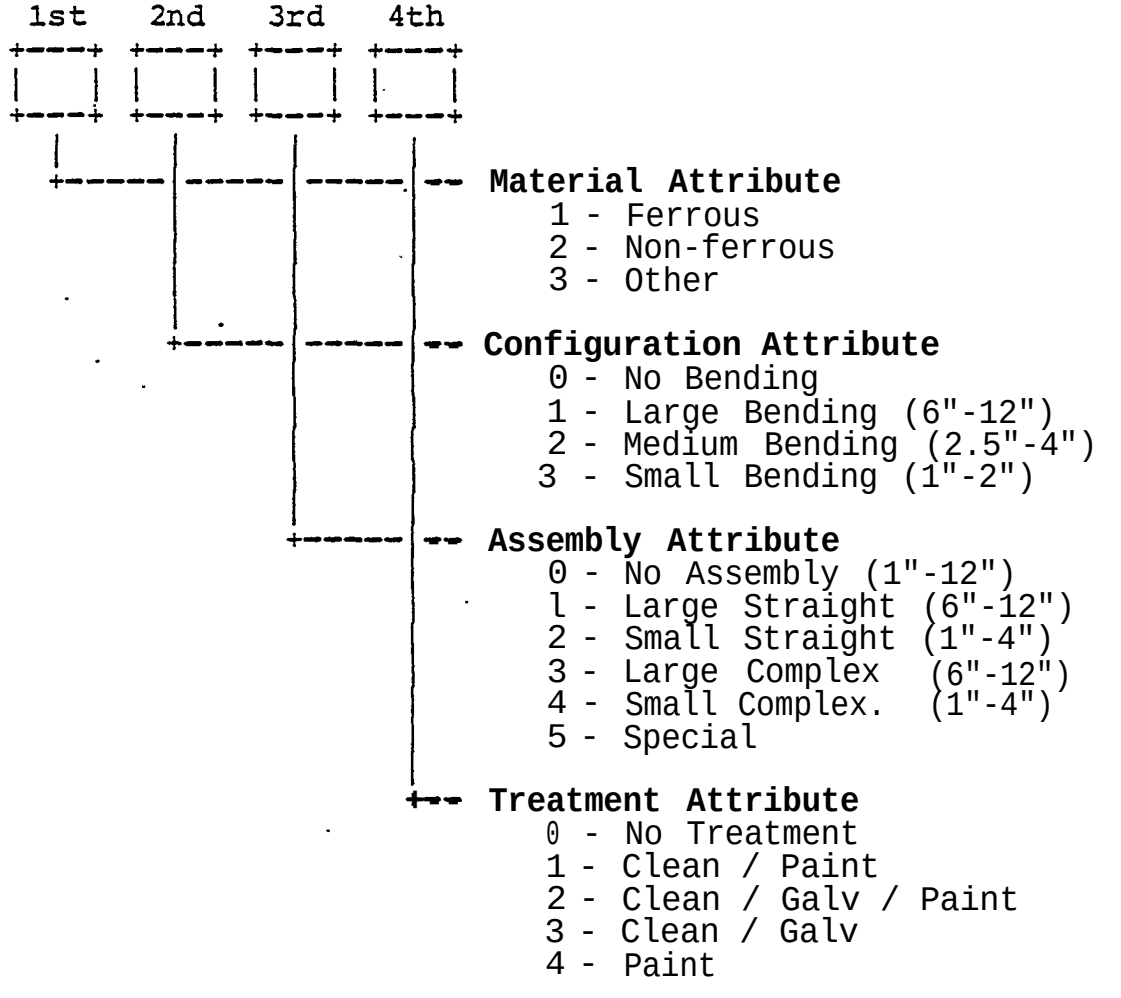


FIGURE II
Family Number Generation

Shop Work Center Definition / Duration Assessment

The fundamental concept of the pipe fabrication manufacturing control philosophy is that the classification system described above can be used to define the routing, scheduling, duration and work content information for any spool by associating it with one of the ninety-three families described above. In this way, detailed production control information can be generated at the spool level much quicker, easier and according to more standardized rationale than if the same information had been generated for each individual spool.

Shop routing for spools is accomplished by associating each spool to a sequence of work centers in the shop based on its family number. There are five work centers defined for the pipe shop, each corresponding to one of the five functional areas in the shop. The work centers are given in Table II.

TABLE II

Shop Work Centers

Number	Work Center
100	Preparation
200	Bending
300	Assembly
400	Treatment
500	Palletize

Every spool manufactured in the pipe shop can be routed through a series of these work centers. The routing is always sequential with routing through preparation and palletizing required for all spools. This generates the eight possible routings shown in Figure III.

100 -> 200 -> 300 -> 400 -> 500
100 -> 200 -> 300 -> -> 500
100 -> 200 -> -> 400 -> 500
100 -> 200 -> -> -> 500
100 -> -> 300 -> 400 -> 500
100 -> -> 300 -> -> 500
100 -> -> -> 400 -> 500
100 -> -> -> -> 500

FIGURE III

Work Center Sequence

The routing is further broken down to sub-centers for work centers 200, 300 and 400, each sub-center corresponding to the possible values for the configuration, assembly and treatment attributes of the family number. Table III illustrates.

TABLE III

Work Centers and Sub-Centers

Work Center 200: Bending

sub-center: 201 - Large Bender

sub-center: 202 - Medium Bender

sub-center: 203 - Small Bender

Work Center 300: Assembly

sub-center: 301 - Large Straight Assembly

sub-center: 302 - Small Straight Assembly

sub-center: 303 - Large Complex Assembly

sub-center: 304 - Small Complex Assembly

sub-center: 305 - Special Assembly

Work Center 400: Treatment

sub-center: 401 - Chemical Cleaning/Paint

sub-center: 402 - Chemical Cleaning/Galvanize/Paint

sub-center: 403 - Chemical Cleaning/Galvanize

sub-center: 404 - Paint

Using this rationale a spool having a family number of 1043 would have the following routing:

100 -> 304 -> 403 -> 500

Once the routing for a spool is established, duration estimates by work center or sub-center are necessary to develop detailed work center schedules at the spool level. Without going into an exhaustive explanation of how these duration estimates were generated, it is sufficient to say that estimates were developed through a systematic and rational analysis with attention given to types of work performed, processing times involved, material handling aspects and in-process storage considerations. These estimates are applied to the pipe spool families at a particular center or sub center. The total estimated manufacturing duration for a family is the sum of the individual center or sub-center duration estimates based on the routing for that particular family. Therefore, if the family above had the following duration estimates:

100 Preparation	1 day
304 Small Complex Assembly	3 days
403 Chemical Cleaning/Galvanizing	4 days
500 Palletizing	2 days

the total duration estimate for the spool that would be used in scheduling the spool in the shop would be 10 days.

Labor Standard Development

Recent studies have indicated that the application of labor standards to planning and scheduling work performed in shipyard outfitting shops can be effective in increasing shop productivity. A MARAD-funded scheduling standards pilot project conducted at Peterson Builders, Inc., Sturgeon Bay, Wisconsin, revealed that work measurement techniques applied to pipe fabrication planning and scheduling were instrumental in reducing pipe fabrication costs. (6)

Early in the development of the classification system for pipe spools at NASSCO it was perceived that work content estimations could be incorporated into the system to provide information on the manloading required in the shop to support defined schedules. Using the industry research at Peterson as a basis NASSCO initiated a project to collect simplified work measurement data in the pipe shop. The data was subsequently reduced to form a preliminary labor standards database which was further reduced to yield work content estimations for spools at work centers and sub-centers in the shop based on their family classification.

It is necessary to clarify the purpose of the pipe fabrication labor standards database mentioned above and to provide a discussion on methods used in its development. Through this discussion it will be clear to the reader that

the work measurement data represents an initial approach to the subject of manloading and manpower forecasting at a shop level and by no means a collection of "formally engineered" labor standards.

The purpose of the labor standards database is to serve as an initial, first-cut approximation of processing times in the shop in order to estimate manloading in the shop for a given shop schedule. To support these efforts, the level of accuracy required can be achieved through an "informal" approach to work measurement data analysis where the accuracy of time standards is not critical. (7)

Work measurement data was collected in the pipe shop over a two month study period. Actual times for specifically defined operations were collected by the individual workers performing those operations and subsequently organized with respect to material, diameter and operation (or process). Charged time for all shop work was also recorded during the study period in order to estimate aggregate shop process and non-process time. Several assumptions were made in this simplified approach to work measurement sampling:

- Individual workers would record their individual process times themselves.
- Variation of measurements taken by the individual workers, while not precise on an individual basis, will form normal distributions around some average value where the range of reasonable measurements can be approximated

- The average value determined for each process recorded in the study can be used to approximate the required effort (expressed in units of time) for that process for planning and scheduling work in the pipe shop.

- Total time charged in the pipe shop is made up of actual process time (time spent doing a recorded study process) and non-process time (personal fatigue and delay time, non-recorded process time, management caused delays).

- The aggregate non-process time in the shop is the weighted summation of all the individual non-process times associated with each shop operation and can be determined by the difference between the total time charged in the shop and the actual process time recorded in the shop, provided that actual process time is recorded for all work in the shop.

- For shop scheduling purposes, the individual non-process times associated with each shop operation can be approximated by the aggregate shop non-process time expressed as a fraction of the total time.

As indicated previously and further illustrated by the assumptions outlined above, the intent of this effort was not to produce a highly-refined labor standards database for pipe fabrication but to generate estimates of work content that were accurate enough to use in the planning and scheduling of work through the shop.

The work measurement data was reduced and re-organized for quantitative and qualitative analysis which subsequently yielded a set of average actual process times by diameter and material. This set of average actual times form the basis of the prelim-inary labor standards database for pipe fabrication at NASSCO. in order to apply the information contained in this database to the specific families defined by the classification system, the individual process times were grouped into combinations, each combination representing the planning time required for a particular pipe spool family at a particular work center or sub-center in the shop. The rationale surrounding the combination of the process times into planning times by family was similar to the analysis carried out in developing duration est-imates for pipe spool families. The result was a manhour matrix where entries represent the estimated work content for a particular pipe spool family at a particular work center in the shop. Therefore, using the previous example, family 1043 may have the following work content estimate:

100	Preparation	0.2 Hour
304	Small Complex Assembly	3.3 Hour
403	Chemical Cleaning/Galvanizing	0.6 Hour
500	Palletizing	0.2 Hour

which would indicate a contribution of 4.3 hours to the scheduled shop load for spools with a family classification of 1043.

Detail Shop Planning / Scheduling

The association of routing, duration assessments and work content assessments to pipe spool families allows for rapid definition of the same for individual pipe spools. This level of planning and scheduling detail is significantly greater than that which had existed in the past. Earlier fabrication control was accomplished at a higher level where all spools, regardless of sometimes significant differences in complexity and fabrication requirements were treated equally and scheduled identically. This lack of visibility impeded the resolution of production control problems in the shop. The manufacturing control philosophy currently being implemented, however, supplies visibility to the machine level, thus establishing the basis for bringing the manufacturing operation into statistical control.

This is not without cost, however. The more detailed approach requires a significant increase in administrative effort to maintain a more detailed system. To partially satisfy this requirement, automated processing on a shop-based microcomputer was implemented which automatically generates schedules for spools by individual work centers and sub-centers in the shop. The flexibility of the shop-based processing system allows for information to be generated in a variety of formats to support the specific information requirements of the supervision in the shop.

Currently, the implementation of detailed shop planning and scheduling based on the principles established in the classification system and utilizing the shop-based micro-computer is underway.

Cost Collection / Performance Measurement

In any manufacturing operation the collection of labor costs associated with the production of parts is necessary in order to pay employees, report performance to budget and compute productivity. The latter requirement is the subject of this section.

Labor charges in the pipe shop are collected by functional area. This facilitates the simple computation of productivity parameters by work center or sub-center by recording center throughput, expressed in units of standard hours, spools, cuts, bends, etc., and dividing the value by

the number of hours charged to each center. In this way, detailed monitoring of productivity down to the machine level can be accomplished.

Collecting costs by functional area represents a significant departure from traditional collection techniques. In the past, labor was charged using a system-oriented work-breakdown structure where charges for all processes in the shop were cumulated thus preventing visibility for individual process costs. The current method of collecting costs defines cost centers or sub-centers which correspond to the work centers and sub-centers previously defined. Using this breakdown, one only needs to know in what area an individual is working in the shop to determine the correct charge number. This greatly improves the accuracy of labor charging in the shop while providing the visibility required for a self-improving manufacturing methodology.

Currently, charges are being collected at the work center level in the shop. Table IV identifies the cost centers and sub-centers currently defined.

T A B L E I V

Cost Centers and Sub-Centers

Cost Center 10: Preparation

Cost Center 20: Bending

sub-center: 21 - Large Bender

sub-center: 22 - Medium Bender

sub-center: 23 - Small Bender

Cost Center 30: Assembly

sub-center: 31 - Large Straight Assembly

sub-center: 32 - Small Straight Assembly

sub-center: 33 - Large Complex Assembly

sub-center: 34 - Small Complex Assembly

sub-center: 35 - Special Assembly

sub-center: 36 - Tank, Hanger and Support Assembly

Cost Center 40: Treatment

sub-center: 41 - Chemical Cleaning

sub-center: 42 - Galvanizing

sub-center: 43 - Painting

Cost Center 50: Materials

sub-center: 51 - Shop

sub-center: 52 - Shop

sub-center: 53 - Storage (Palletizing)

5.0 CONCLUSIONS

Summary

The pipe fabrication modernization project initiated at NASSCO in the fall of 1983 identified five major objectives as key elements to modern pipe fabrication:

- o Dictate the design of the spools to conform to facility constraints and optimum fabrication techniques.
- o Gain organizational control over the total manufacturing process.
- o Increase the level of fabrication technology in the pipe shop.'
- o Simplify and streamline product flow and process sequence.
- o Develop consistent methods to plan, schedule, route, collect cost and compute performance with respect to the manufacturing processes involved.

With respect to the first objective, continuing efforts are being directed into the Engineering/Production interface to insure spool design that supports efficient spool manufacturing. Included in this interface is a continuous transfer of fabrication methodology so that designers can develop design "principles" that support the production effort rather than "rules" which must be followed without necessarily understanding the reasons why.

With the centralization of the manufacturing operations into one shop, organizational control was also centralized.. Currently, all manufacturing operations from the in-process

storage of pipe and fittings to the palletization of painted pipe spools are the responsibility of the individual responsible for pipe spool manufacturing.

The facility enhancements associated with the modernization project will complete early in 1986. Outstanding items are the installation of the preparation line and installation of the straight pipe processing station. The completion of these items, as well as the enhancements completed thus far represent a significant increase in the level of fabrication technology in the shop and a substantial improvement in the streamlining of the work flow in the shop.

The group technology-oriented manufacturing control philosophy is partially implemented with full implementation to follow the completion of the preparation line. This philosophy integrates all elements of manufacturing control by utilizing group technology principles with respect to pipe fabrication.

Assessment of Productivity Improvement

The lack of significant labor returns to date as well as the incomplete status of the overall project prevent quantitative discussion of the productivity improvement currently being experienced in the shop. It appears, however, that throughput capacity has increased substantially. Analysis of throughput data for the past several years indicates sustained throughput values much higher than traditional values at the same unit cost (hour/spool).

It is the opinion of the author that with effective management in the shop and complete implementation of the methods dicussed in this report, productivity in the manufacturing of pipe spools can be improved by 100 percent over traditional values. In other words, the cost per spool considering the total manufacturing effort will be cut in half.

Anticipated Programs

The modernization program for pipe fabrication described in this report represents the initial phase of a continuing effort to provide state-of-the-art facilities and manufacturing technologies in the pipe shop at NASSCO. Long-range planning has identified programs in several areas which also support this goal. Three of these programs are identified below.

The application of statistical process control (SPC) techniques has been shown to be effective in manufacturing environments for the control of quality and subsequent improvement in manufacturing efficiency. The implemetation of SPC techniques in the pipe shop at NASSCO is supported by the simplification and streamlining of the product flow through the shop. SPC is considered to be a necessary element in continuing to improve the productivity in the pipe shop.

The manufacturing sequence currently defined in the pipe shop is a significant improvement over traditional operations. A further improvement recognized as necessary in the optimization of product flow through the shop, however, is the implementation of straight pipe fabrication prior to bending and assembly. This operation would minimize fabrication costs by utilizing highly efficient straight pipe processing wherever possible. The assembly bays would be utilized for final assembly of straight or bent pipe pieces into pipe spools. Manual fitting and welding would be minimized.

The design and creation of the supplementary instruction sheets (spool sheets) used to provide manufacturing information to the pipe shop is currently a manual process. Three-dimensional CAD (Computer-Aided Design) systems are capable of automatically generating material lists, classification data and manufacturing data for piping systems. The installation and implementation of CAD facilities in Engineering for automatic generation of pipe spool manufacturing data supports the modernization effort with respect to pipe fabrication at NASSCO.

Human Factors

It must be recognized that the success or failure of any project, whether it involves the installation of new facilities or implementation of new methodologies, is dependent on how well the personnel affected assimilate to

the changes introduced. This is particularly true when responsibilities are expanded or areas of concentration redefined.

Several steps can be taken to insure adoption of new methods and optimum utilization of new facilities. The involvement of affected personnel early in the design process will not only create a sense of ownership but will many times reveal deficiencies in the design that would have later resulted in operational problems. Developing an understanding in the affected personnel of the principles and key Objectives of the change eliminates automatic response to problems and replaces it with systematic solutions. Continuous' training in terminology, procedure, methods and policies deters confusion and uncertainty associated with change.

To reiterate, only with the support and enthusiasm of the individuals who will be responsible for the execution of the changes proposed will the efficiencies estimated in design be approximated in the "real" world.

REFERENCES

1 The National Shipbuilding Research Program, U.S. Department of Transportation, Maritime Administration: "Pipe Piece Family Manufacturing," March 1982.

2 The National Shipbuilding Research Program, U.S. Department of Transportation, Maritime Administration: "Semi-Automatic Pipe Handling System and Fabrication Facility Phase II - Implementation," March, 1983.

3 Hyde, William F.: "Improving Productivity by Classification, Coding and Database Standardization," 1981, page 152.

4 Ibid, page 45.

5 Ibid, pp 49-50.

6 Corporate Tech Planning, Inc,: "Scheduling Standards Pilot Project," 1982.

7 M. Fein: "How 'Reliability", 'Precision' and 'Accuracy' Refer to Use of Work Measurement Data," Industrial Engineering, July, 1981.

ZONE OUTFITTING

IN A CANADIAN GREAT LAKES SHIPYARD

(The First Four Years)

BY

Alan J. Telfer

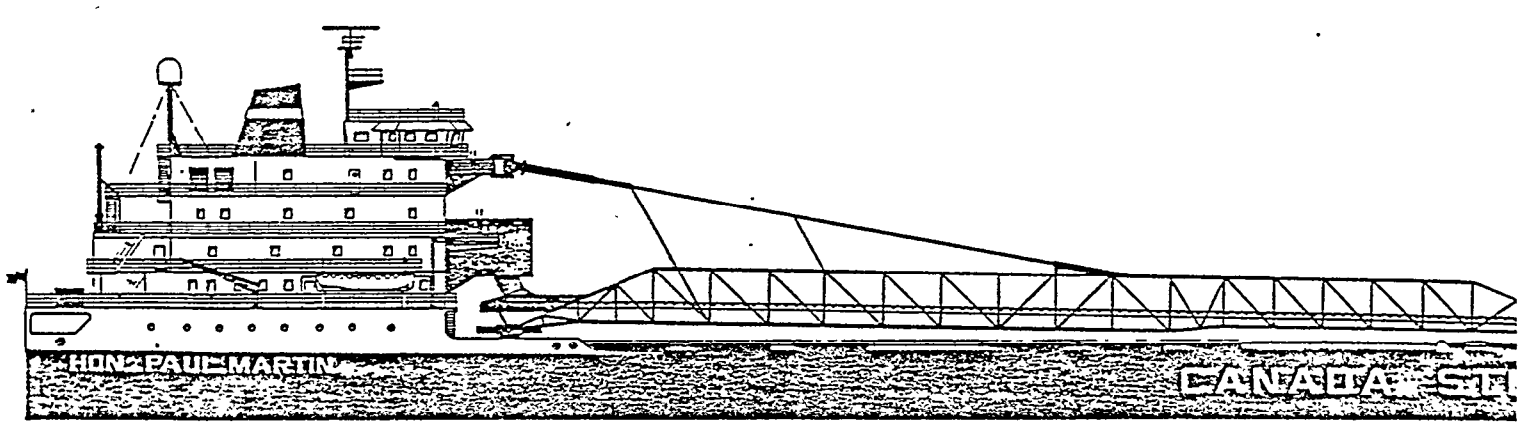
Chief Planner

COLLINGMOOD SHIPYARDS

ONTARIO

FEBRUARY

1985



HULL 225 PRINCIPAL PARTICULARS

Length Overall	224.50 m -- 736'-6½"
Length B.P.	217.97 m--715'-1½"
Breadth (Moulded)	23.120 m -- 75'-10½"
Depth (Moulded)	15.250 m -- 50'-0'
Total Deadweight	39,000 t — 38,400 L.T.
Summer Draft	10.380 m — 34'-0-5/8"

Main Engine	1 x Sulzer 6RLB66
Horse Power	11,100 BHP MCR
Speed	14 knots - 16 MPH
Classification by Lloyd's Register of Shipping	100A1 Bulk Carrier Self-Unloader Part HT LMS
Complement	36 Persons

1. SUMMARY

This paper traces the introduction of Zone Outfitting and Outfit Modules in a Canadian Great Lakes shipyard following ideas put forward at a Washington, D.C. seminar in 1981.

Advances made-during construction of five 736' bulk carriers are presented showing the increase in outfit material incorporated in steel units before erection and the rapid increase in size of machinery modules from 3 - 4 tons to some of 40 tons.

The different attitudes to these changes by senior management, production supervisors, drawing office and mechanics are briefly examined.

Some of the problems encountered will be discussed along with the benefits gained by different departments in the yard. The paper will examine problems which have yet to be overcome with a look at new advances planned for future ships.

This is a report on the advantages of Zone Outfitting introduced into a yard possessing only a medium sized Technical Department and a small Planning Department, but with a willingness to accept change. We have not found all the answers, and cannot adopt all of the techniques available to larger yards, but it is hoped that our progress over a period of four years will be interesting to yards in similar situations.

2. BACKGROUND

Collingwood Shipyards has been in business for over 100 years and the yard has established a good reputation for building vessels of all types. In recent years, however, a large number of Great Lakes self-unloaders and bulk carriers have been built. These vessels are 736' long and designed to pass through the St. Lawrence Seaway, some of these ships are full ocean going class. The shipyard normally employs about 1000 workers; the steel shops can process 15,000 tonnes of steel a year; there is one main building berth with a crane capacity of 120 tons. These resources enable the yard to construct two full Seaway size ships a year. Hulls are launched sideways into a narrow outfitting basin - this provides a popular spectacle for visitors to the town, which is positioned on Georgian Bay, an extension of Lake Huron. The area receives an annual snowfall of 100" and is the skiing center of Ontario.

In winter the temperature drops occasionally to minus 30°C. and ships cannot be launched or delivered during the first three months of the year due to ice conditions in the harbour and the closure of the St. Lawrence Seaway. Ships are normally built with the engine room at the exposed north end, of the building berth. There are, therefore, good reasons for moving as much work as possible indoors.

3. INTRODUCTION OF ZONE OUTFITTING

We have to go this way" - GENERAL MANAGER

In 1981, two members of the Planning Department and a Chief draftsman attended a seminar on Japanese Shipbuilding Technology, in Washington, D.C., given by Lou Chirillo. The seminar was repeated in Collingwood for Technical Departments and Production Supervisors. From these two seminars, a positive approach was made to include more outfit work in steel units before erection on the berth.

As the superstructure units of the ship then on the berth passed through the Assembly Shop, some pipework, ventilation trunk, heater boxes, windows and sidelights were installed before erection. Problems were encountered almost immediately due to the location of erection butts clashing with the positions of outfit material on the deckhead. This information was passed to the Drawing Office to ensure that outfit drawings for the following ship located: material 'clear of erection butts. Make-up pieces were located where systems ran across butts. The outfitting foremen lost no opportunities in advertising problems they encountered on the first ship.

From this simple beginning Collingwood has advanced fairly 'quickly into zone outfitting. The outfit trades now expect as much work as possible to be carried out away from the berth and have begun to carry out additional work on their own initiative - surely a healthy sign.

4. DEVELOPMENT OF ENGINE ROOM PUMP MODULES

"We won't get this one out of the shop" - PIPEFITTERS FOREMAN

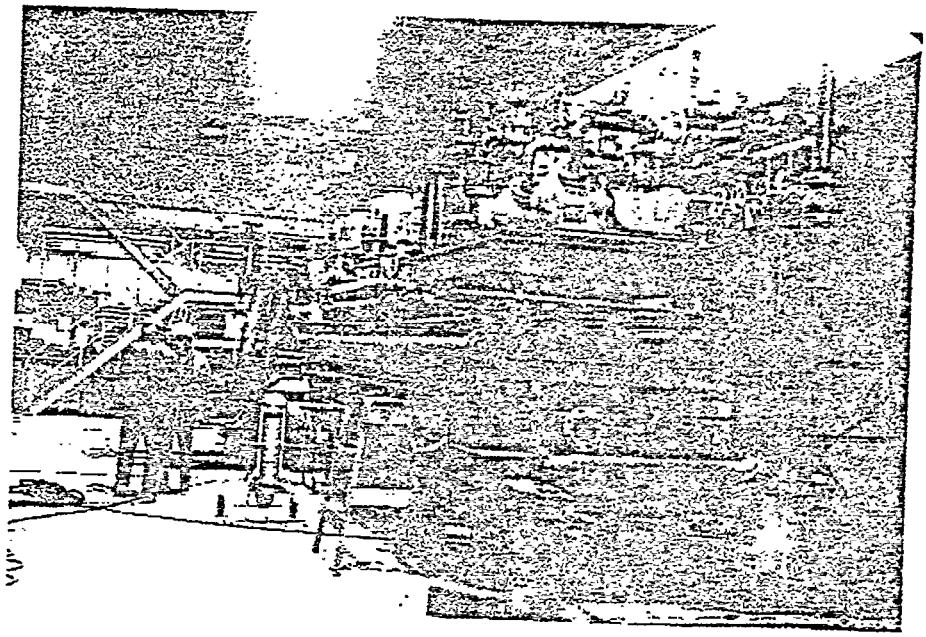
At the time of the seminars, a self-unloading bulk carrier was under construction. In this ship each auxiliary in the engine room was mounted on its own individual seat. Seats were lifted on board one at a time, installed, and the auxiliaries followed individually - pipe pieces were fitted after the auxiliaries were on their seats. This was the normal procedure.

On the following ship, some pumps were grouped closer together on larger shared seats and connecting pipework installed in the Pipeshop before erection at the berth. The seats were still made from plate and this resulted in problems when running pipes under the enlarged seats.

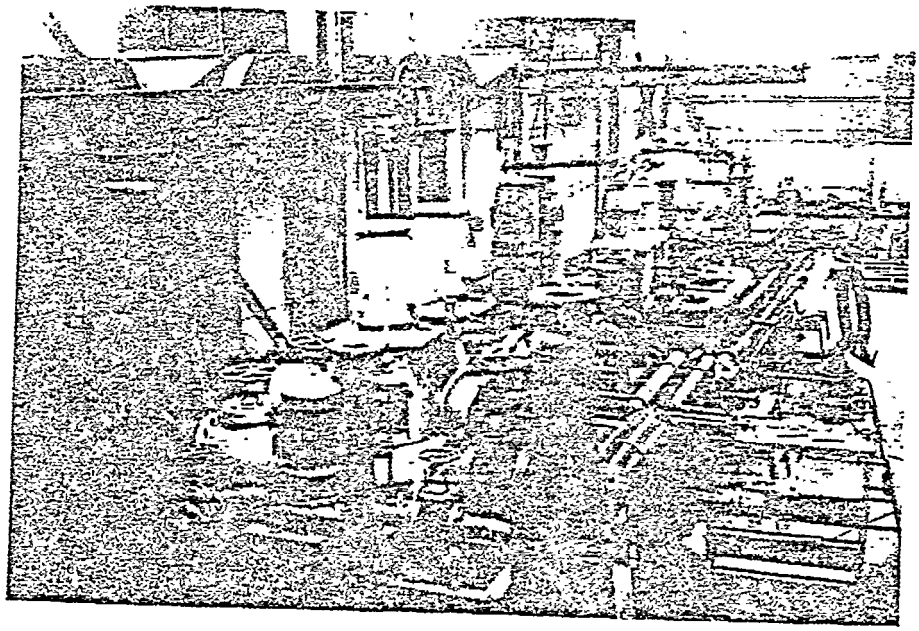
Seats were redesigned for the next ship (1982) using steel channel instead of plate. These were larger simpler seats with flat areas at the engine room floor level, permitting installation of floor plates at a much earlier stage of construction.

The first modules built were within the 5T lifting capacity of the Pipeshop cranes. The second ship's modules were too heavy for shop cranes and were handled by mobile cranes. By the beginning of 1984 some modules were too large to pass through the Pipeshop doors. Two new ballast modules were, therefore, built outside the‘ shop under a small crane, installed for this purpose.

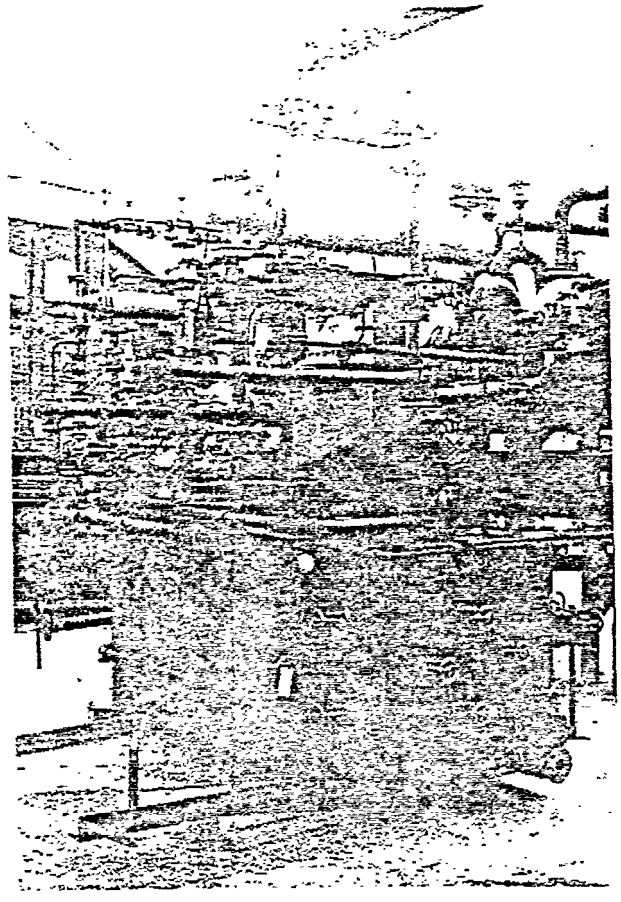
We also began to build modules for smaller diameter pipe systems, some of these were built on top of independent tanks. There had been a natural inclination at first to concentrate on larger diameter pipe systems.



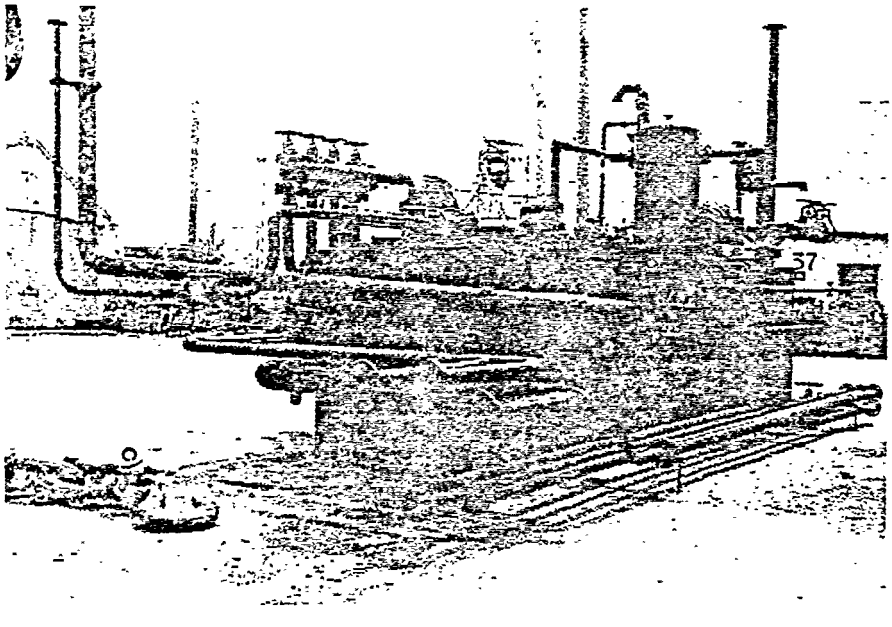
Two Modules in Pipeshop



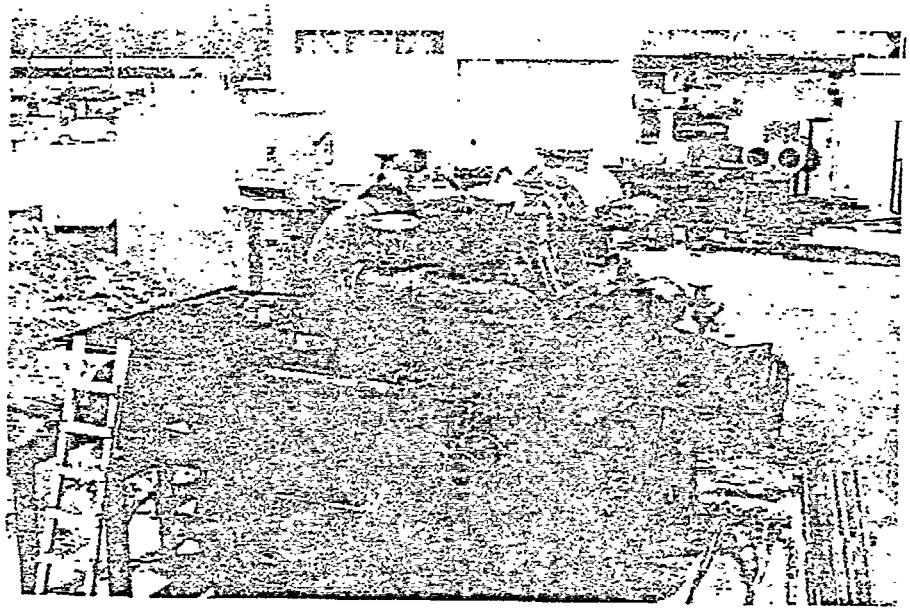
Two Modules in Pipeshop



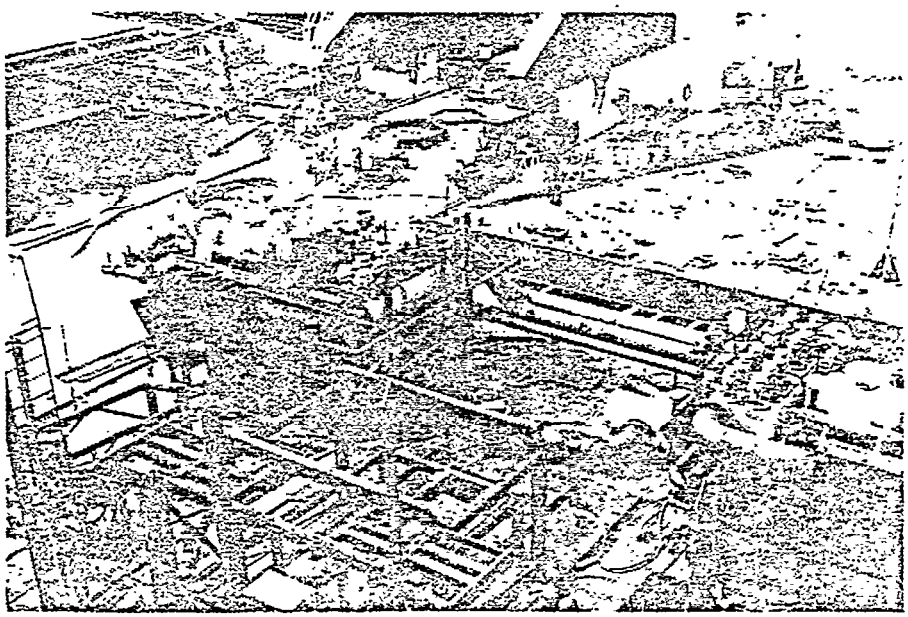
Tank used as Module Seat



Tank used as Module Seat



Ballast Nodule Construction



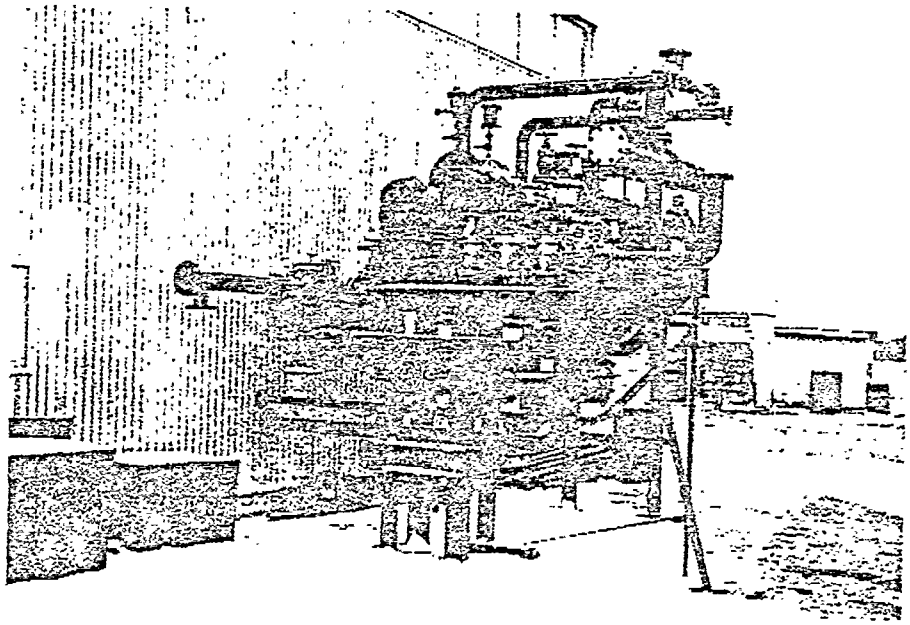
Bailast Modules on Berth

The Drawing Office had now (1984) moved to composite drawings for the Engine Room. This change led to a natural enlargement in size of modules, since a pipe from another system passing in the vicinity of a module could be relocated at the design stage and included in the module. The new "framework" seats were ideal for supporting pipework.

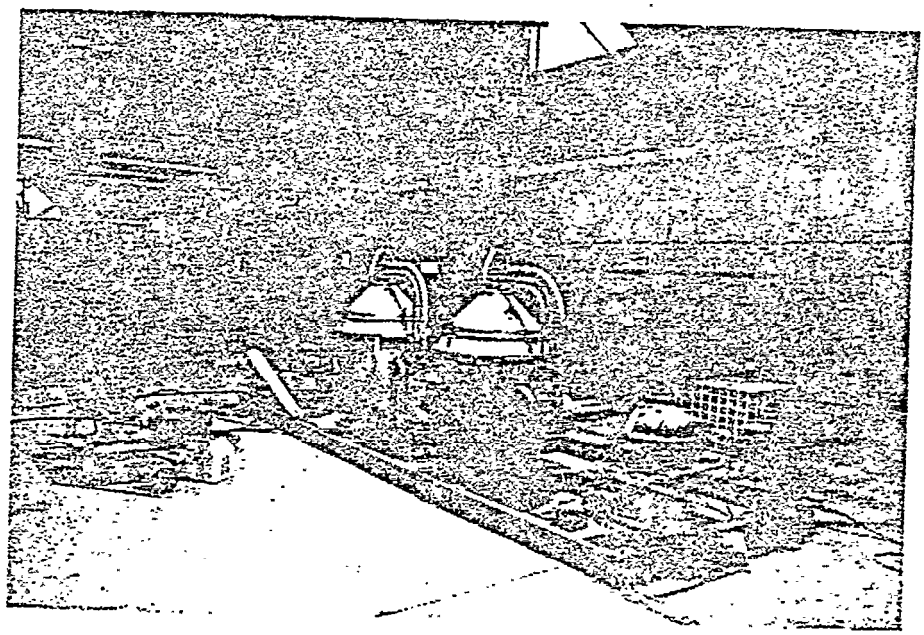
The fuel oil purifiers with their associated pumps and heaters are located in a separate compartment in Coldingwood-built ships. The compartment contains a mass of pipework which was normally installed after the major pipe systems in the lower engine room. The location of the Purifier Room in the ship prevented it from being built as a separate steel unit and outfitted at the Pipeshop. A compromise solution has been achieved by installing all auxiliaries on two low seats which have a light vertical framework fitted to the rear edge. The framework is used to support items previously mounted on the Purifier Room bulkhead.

The production of modules imposes more work on the Drawing Office since Production demands drawings for seats and modules at an early stage of construction. Some of the smaller diameter pipe systems, such as steam and purifier piping, are required several months earlier than before.

The Purchasing Department is also placed under pressure to get material into the yard earlier.



Bilge Pump Module



Purifier Module

5. ENGINE ROOM CASING MODULE

"We don't need the riggers this time" - SHEET METAL FOREMAN

Outfitting the Engine Room Casing in the short period between erection of the superstructure and launch, had always been difficult. It required 90 separate lifts by the berth cranes to install material in the casing over the eight-week period leading to launch. Staging had to be re-adjusted continually and there was always a risk of men slipping or dropping tools into the Engine Room below.

In 1984 the first Casing Module was built. This was a free-standing framework which was outfitted with ladders, handrails, walkways, ventilation trunks, exhausts, tanks, vents, main engine economizer etc. The whole structure weighed 37 tons. The construction of this module benefitted more trades in the yard than any other. The module was outfitted on the ground at the end of the berth and was very "visible" to men walking to the berth.

Installation was carried out in one crane lift, which lasted 2 hours.

Note: The casing module for the next ship has been extended by a deck and contains more equipment. For example, the lights have been run on a single "vertical" circuit to enable them to be fitted and wired.

5. ENGINE ROOM CASING MODULE

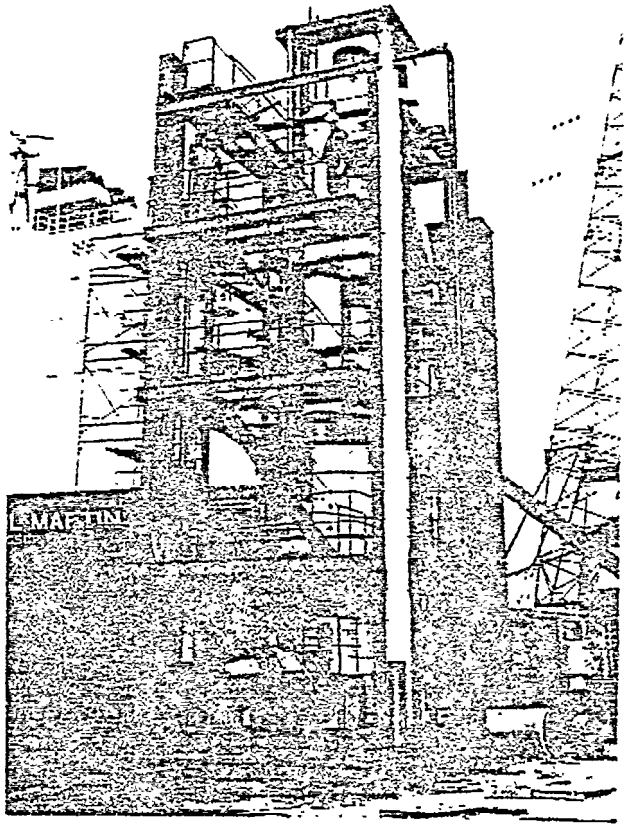
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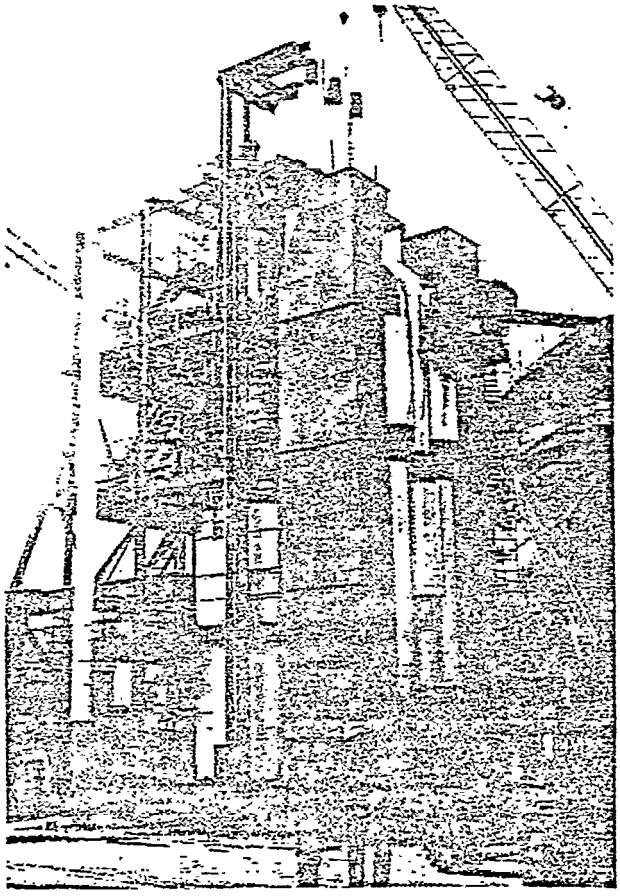
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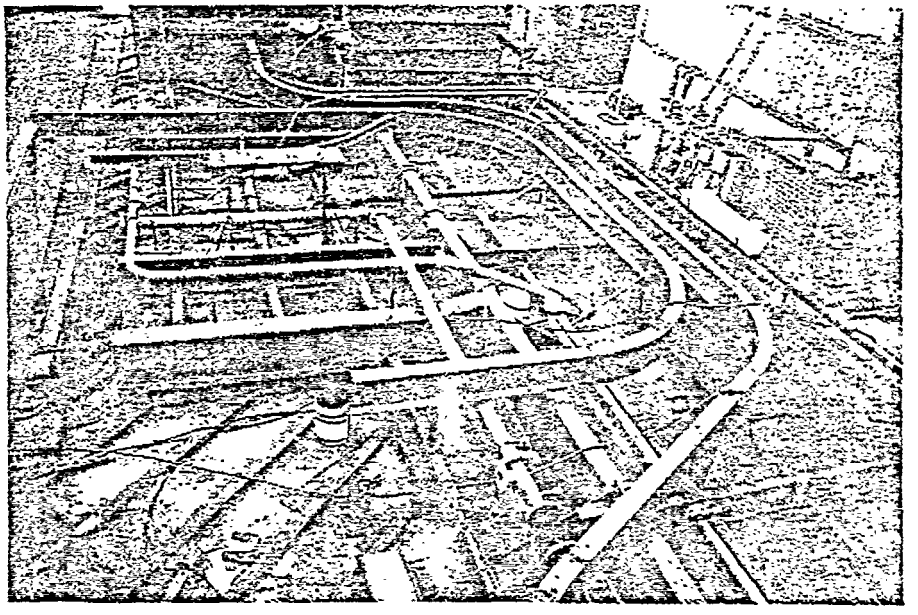
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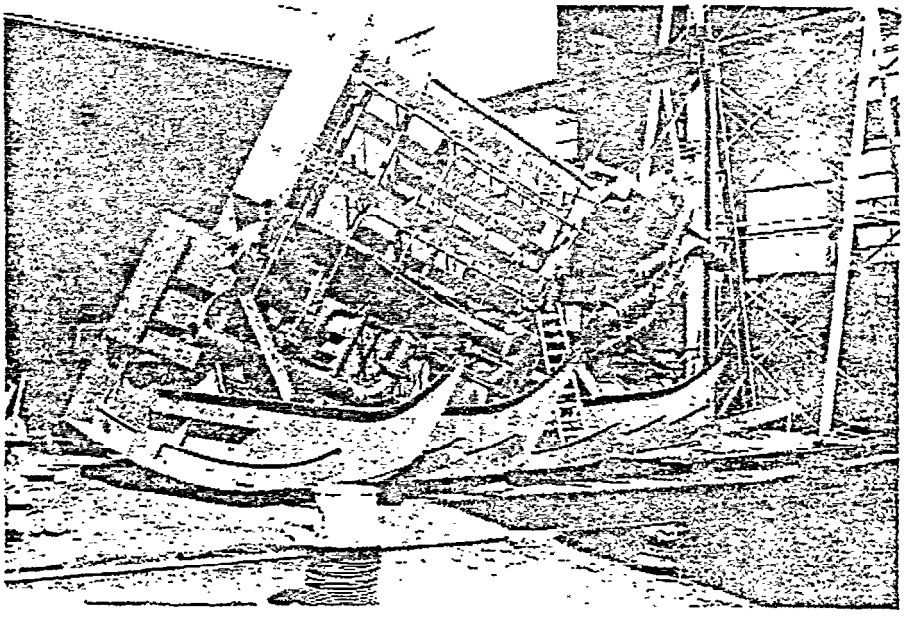
Engine Room Casing Module







Engine Room Deckhead in Assembly



Engine Room Deckhead Out of Assembly

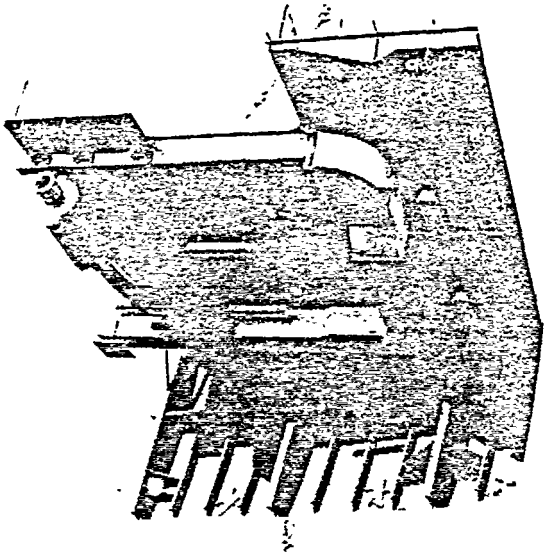
6. ENGINE ROOM STEEL UNITS - ZONE OUTFITTING

"There are too many Outfit Trades in my shop" - STEEL ASSEMBLY SHOP FOREMAN

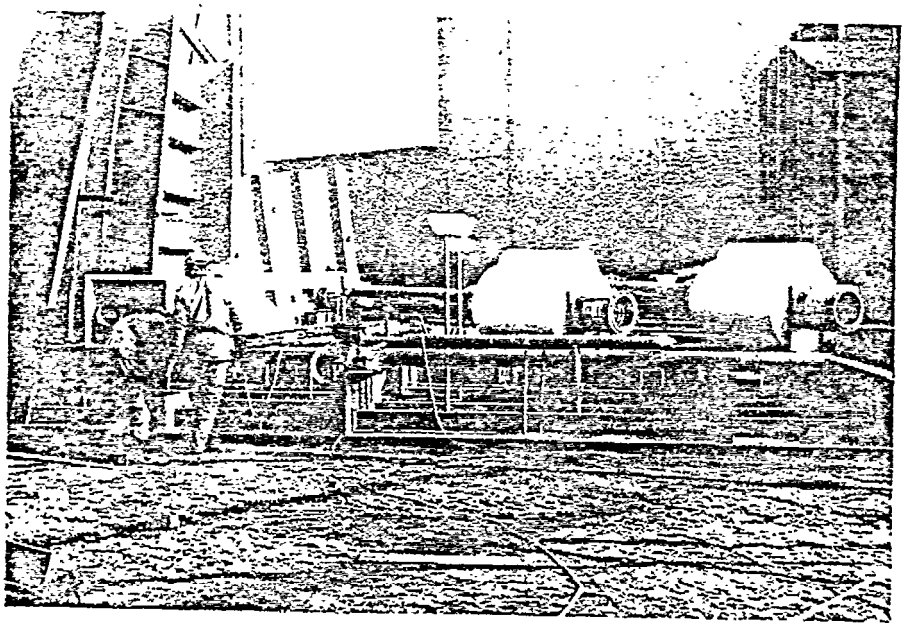
Before 1981 the only outfit -items fitted to engine room units were coolers suspended under the Machinery Deck. Zone outfitting has now progressed to the point where permanent lighting, electrical trays, lighting cables, monorails, ventilation trunk, generator silencers, exhaust piping and major pipe runs are fitted "down hand" in the Steel Assembly Shop. Seats on the deck are normally fitted when the unit is turned upright before erection. We try to apply two coats of paint before erection, but unit painting is often difficult to guarantee due to weather conditions.

When the outfitting trades were introduced to down hand work in the Assembly Shops, a separate time slot for this work was not introduced to the schedule. This was deliberate in order to discover if service trades could support outfit work in addition to steel work already in hand. There has been no noticeable delay to steel and with very few exceptions, the outfit trades complete their work before the unit is ready to move from the Assembly Shop. This method avoided setting up a separate work center for the outfit trades with supporting service trades. A covered site was not available and carrying out the work under cover in the assembly shop was regarded as being of prime importance.

On a ship launched in 1984, the permanent fluorescent lights in the lower engine room were in use six months earlier than previously, and main cable installation commenced ten weeks before launch.



Engine Room Deckhead Erection



Engine Room Out of Assembly

7. SUPERSTRUCTURE UNITS - ZONE OUTFITTING

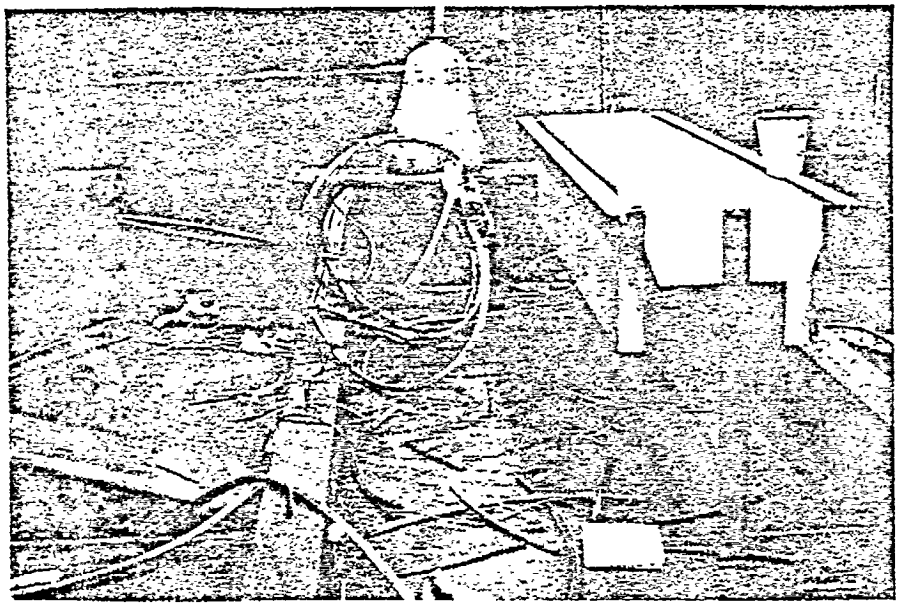
"If we weren't doing this we would be unemployed" - PLUMBER WORKING IN ASSEMBLY SHOP.

Before 1981 the yard had fully outfitted the superstructure of a small tug before erection, but the concept of fitting material down hand had not been tried by the outfit trades and they were reluctant at first to venture into the Assembly Shop. The advantages were soon realized, however, particularly by the men carrying but the work. The trades involved, Plumbers, Joiners, Sheet Metal and Electricians, were unfamiliar with "upside-down" work but solved the problem of locations by securing a second set of drawings printed in reverse.

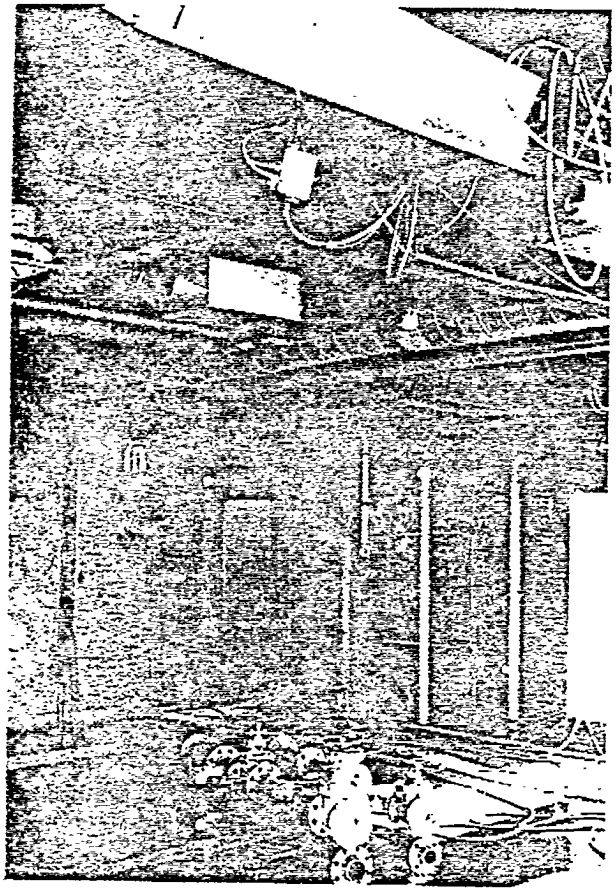
Superstructure units at Collingwood are normally erected as single tier units and are now outfitted with cable trays, lighting cables, permanent lights, waste and drain pipes, hot and cold pipes, W.T. doors, seats and auxiliary machinery, ventilation trunking, ladders and stairways. Two coats of paint are applied before erection and seats are fitted to the top of units after they have been turned upright.

Windows and sidelights have been installed but due to a new design of interior bulkhead panels, these now have to be fitted at the berth.

Composite drawings are used for installation of pipes, vent trunks, lighting etc., under the superstructure decks.



Accommodation Deckhead in Assembly



Accommodation Unit Erection

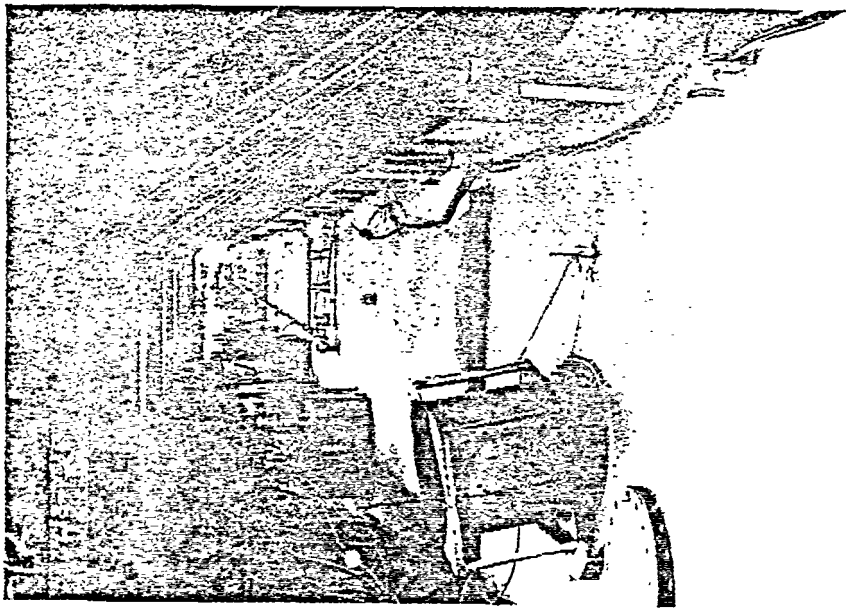
8. MID-BODY ZONE OUTFITTING

"We won't need staging" - PLUMBER FITTING VENT PIPES

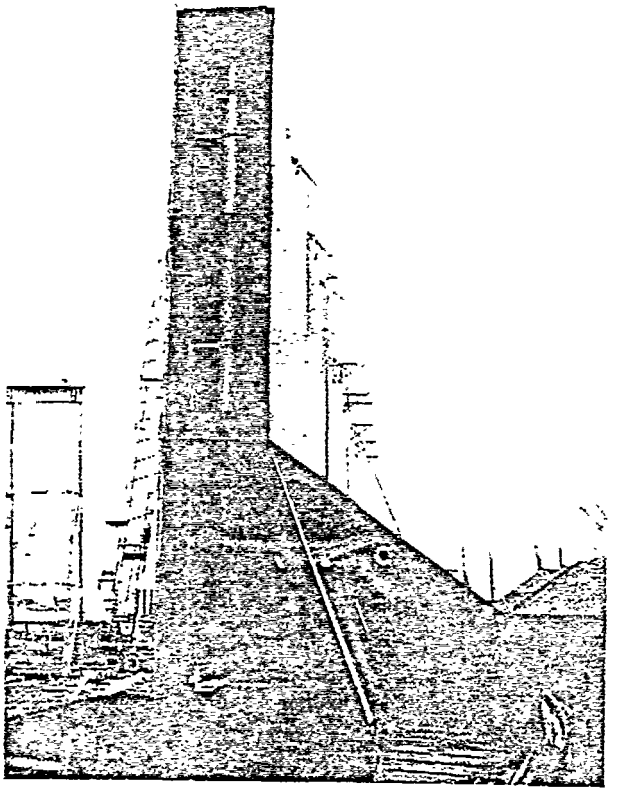
There is little outfit work on the mid-body of a bulk carrier. Tank vents and sounding pipes, ballast pipes, ladders and walk-ways are fitted in Assembly.

Additionally on a self-unloader, the permanent lighting under the hoppers, fire main pipes, HP air pipes, and center line tank pipes are fitted.

Since we started fitting permanent--light fixtures and their cables in Assembly, the number of lamps broken due to vandalism has dropped remarkably. The manhours spent on maintenance of temporary lights is now 50% less than before.



Ship's lighting in use on Berth



Mid-Body Pipes Fitted in Assembly

9. ATTITUDES

"The innovator has for enemies all those who have done well under the old conditions" - MACHIAVELLI.

The attitudes displayed by different departments in the yard to the changes being introduced were interesting. The men carrying out the work were instant converts, the foremen perhaps the slowest to accept the new methods. The former, possibly because of the obvious physical advantages of carrying out heavy work down-hand, indoors. The latter, because of a natural reluctance to accept changes in their established practice.

QUOTATIONS - ANON

"The wheelhouse will collapse if we burn the window openings before erection" (1981)

"The wheelhouse windows will crack if we fit them before erection" (1981)

"You can't fit the mast to the wheelhouse before erection" (1983)

"My cable trays will be damaged if they are fitted in Assembly" (1981)

"My cables will be damaged if they are fitted in Assembly" (1982)

"My lights will be damaged if they are fitted in Assembly" (1983)

The Drawing Office responded positively to almost all suggestions for changes and have now taken on the role of instigators at the design stage. During this period, CAD/CAM systems were also being introduced to the Drawing Office, and they were under a heavy work load.

In Collingwood, the responsibility to push the new methods fell on the Planning Department at first, since the ships under construction in 1981-82 were complete as far as drawings were concerned.

The Drawing Office influence took effect on later ships, when the methods had been seen to work and basic layout drawings for later ships started with the new concepts in mind. It is more important to sell the ideas being tried on the first ship attempted, to the draftsman, than to the mechanic doing the work. It is essential that Production management support the change. Superintendents have a wider field of view than trade foremen and can see the overall advantages, whereas a foreman quite naturally looks at life from his own trade position. The outfit foremen were all concerned that "their" material would be damaged by other trades if it was fitted in Assembly, and in some cases they were right. A few pipes, trays, and lights were damaged.

Senior managers have to be behind the drive-to change to zone outfitting. Their influence must be available since demands from Production for earlier drawings, pipe sketches and material have to be met. Pump modules must be completed at the latest before the deck above is erected. This cannot' be achieved with the conventional delivery dates for pumps and valves.

10. BENEFITS RESULTING FROM ZONE OUTFITTING

"How much are you saving me?" - GENERAL MANAGER

There are obvious advantages in carrying out work in the shops which had previously been undertaken at the building berth, e.g better access to stores, closer supervision, superior working conditions, less walking time. Some of these items are difficu1t to quantify.

(a) Walking Time

Walking time, however, can be calculated between two work centers quite easily. In Collingwood, the walking time for a man between the building berth and the Pipeshop is 4 minutes, or almost 4 hours per week, i.e. every Pipefitter working on the berth is in effect paid to "walk about" the yard for half a day each week. Looking at it another way, the man spends five weeks a year on a "Sponsored walk" by the company. This alone is good reason to move as much work as possible to the Pipeshop.

(b) Condition at Launch

Extending the overlap of outfitting work into the steel schedule will reduce the duration of the contract. Ships in Collingwood are now more complete when launched than in the past. This is not due to delaying the launch date. With only one available building berth, ships are normally launched as soon as possible to free the berth for the next contract. Fig.10(b) shows the state of completion of a number of hulls at launch over the period when zone outfitting was introduced. Note that ships are launched at a constant state of completion for steelwork, note also the increased level of outfit work, (Hulls 226 and 224 had different engines from the other ships and are not included in the "Machinery" figure).

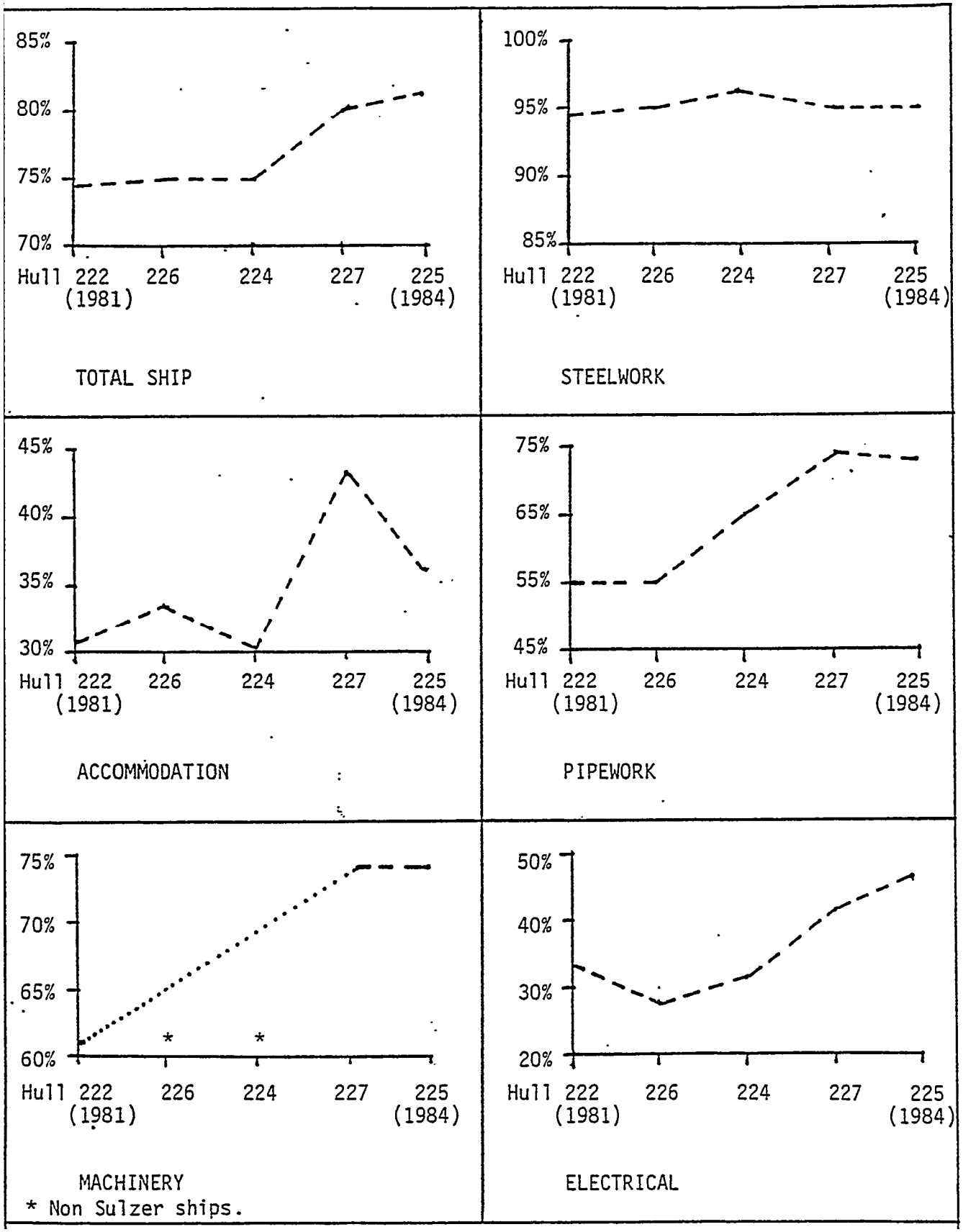


FIG 10(b)

State of completion at launch-during the introduction of zone outfitting on five ships.

(C) Engine Room Modules

There have been a number of labour cost reductions which can in part be attributed to the move towards modules. Fig.10(c) shows some of the changes. Note the rise in cost of auxiliary seats on Hull 225 compared to Hull 227, due to construction of two large additional seats for the ballast system, the cost, however, was still less than on Hull 222. The true benefits of moving to modules is difficult to calculate as-there are spin-off effects. For example, the berth cranes are now available for other systems in the ship, engine room floor plates can be fitted earlier, less staging is required, fewer men are in the engine room,

(d) Engine Room Zone Outfitting

Fig.10(d) shows some of the labour savings achieved in the Engine Room. There were again, however, a number of benefits which are difficult to measure. It took a great deal of persuasion to convince the electricians that it was possible to install and wire permanent fluorescent light fittings before erection, a few lamp fittings were, in fact, damaged as panels were erected, but the cost was small compared to the improvement in working conditions. The cost of temporary lighting was also reduced. There is no practical reason for permanent lighting on a steel unit not to be operational a few days after erection at the berth.

One advance led to another. Since almost all cable tray was fitted before erection, cable runs were installed earlier. Space heaters and fan trunking were also fitted in the Assembly Shop, the engine room can, therefore, be illuminated, heated or ventilated at a much earlier stage.

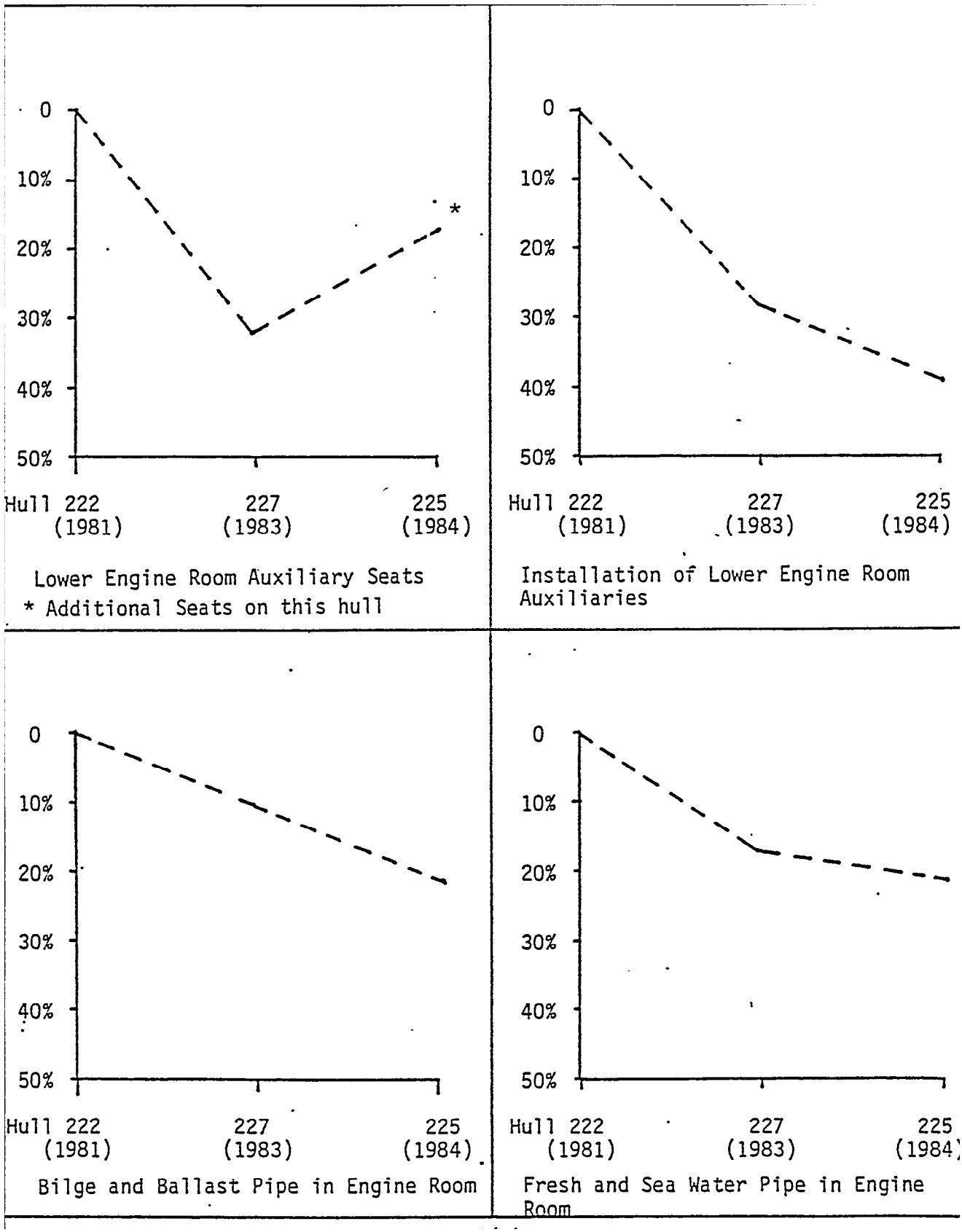


FIG. 10(c)

Reduction in Lower Engine Room Manhours following introduction of Pump Modules

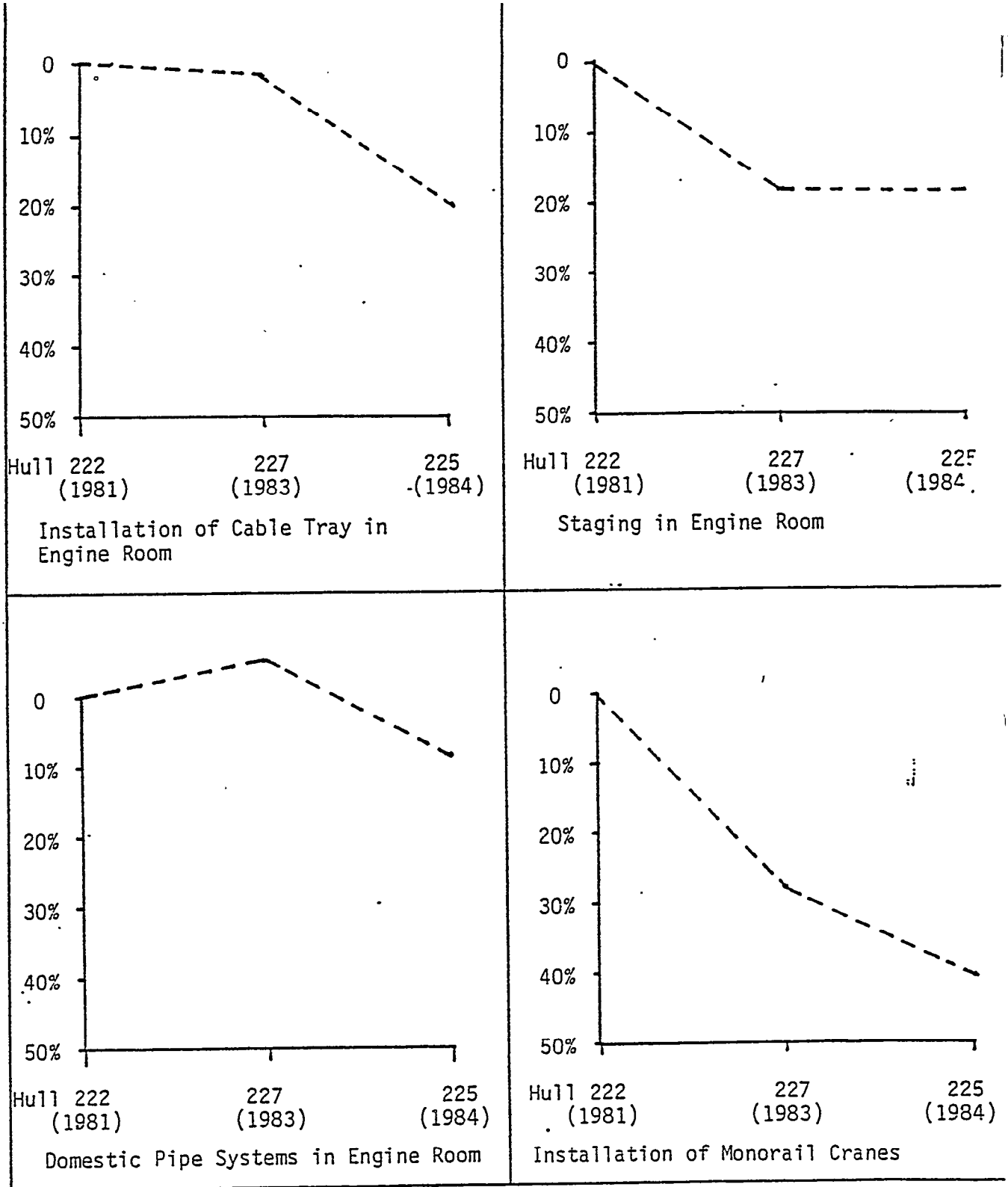


FIG. 10(d)

Reduction in manhours following introduction of zone outfitting in Engine Room.

(e) Accommodation Zone Outfitting

The advantages in the Accommodation follow the pattern of the Engine Room, better working conditions and an earlier start to some types of work. Fig.10(e) shows some of the manhour savings.

(f) Engine Room Casing Module

The first casing module was built in 1984 and was the largest and by far-the most spectacular module to date. There were the obvious advantages of construction close to the Pipeshop, no requirement for the berth crane etc. Once again, however, the less than obvious advantages became important:

The casing at the ship was open for access to the Engine Room until three weeks before launch.

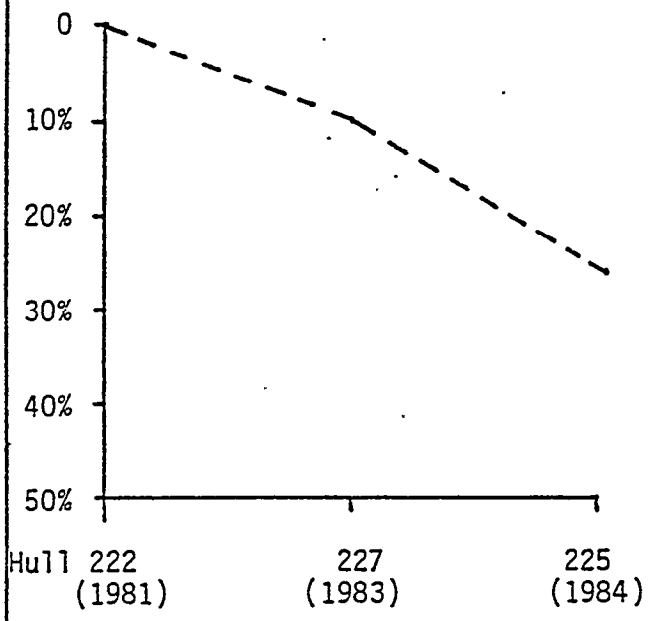
Ladders, walkways and handrails in the module were available for use immediately after erection, and in fact, were used during erection of the module.

Insulation of equipment in the module was completed before erection, thereby eliminating the problem of dust falling into the lower engine room.

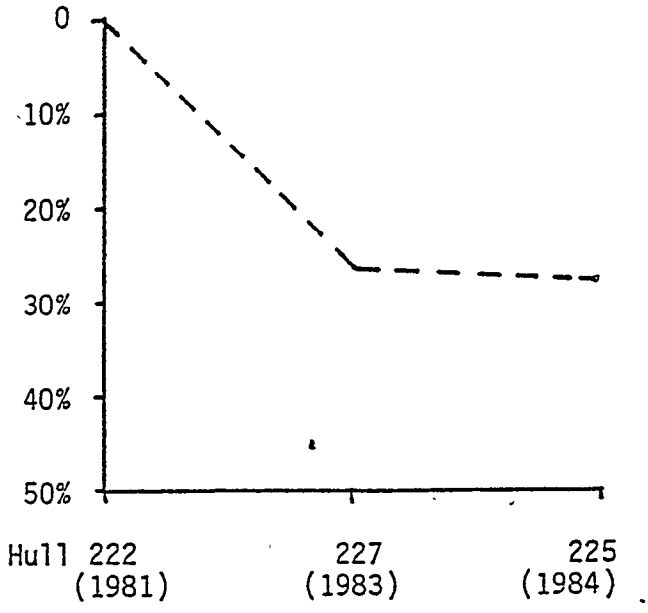
The pipefitters, acting on their own initiative, installed a large number of smaller pipes which had not been designated by Planning.

(g)- Safety

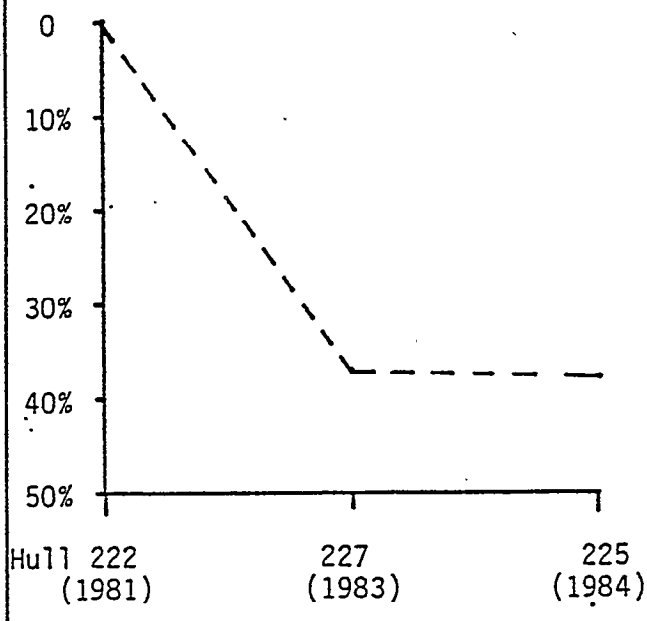
Unfortunately we cannot claim any positive reduction in accidents and subsequent drop in compensation payments due to zone outfitting, but common sense dictates that better lighting, less overhead work, less work on staging, earlier installation of permanent ladders and walkways is both safer and healthier for the work force.



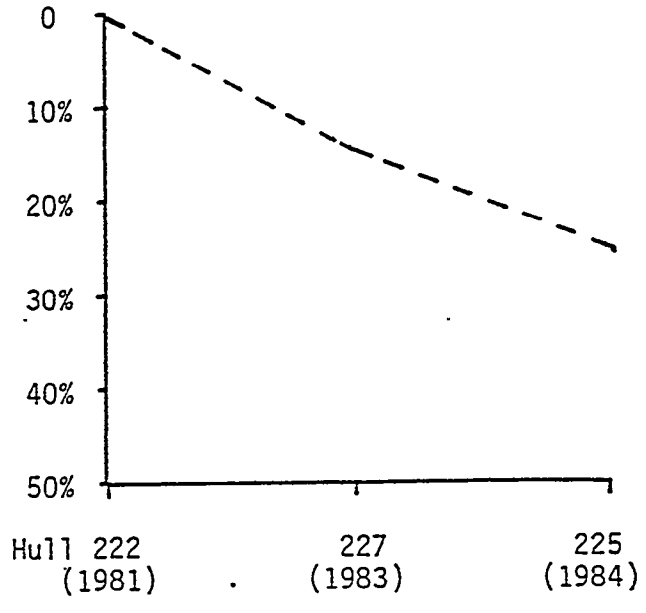
Installation of Cable Tray in Superstructure



Staging in Superstructure



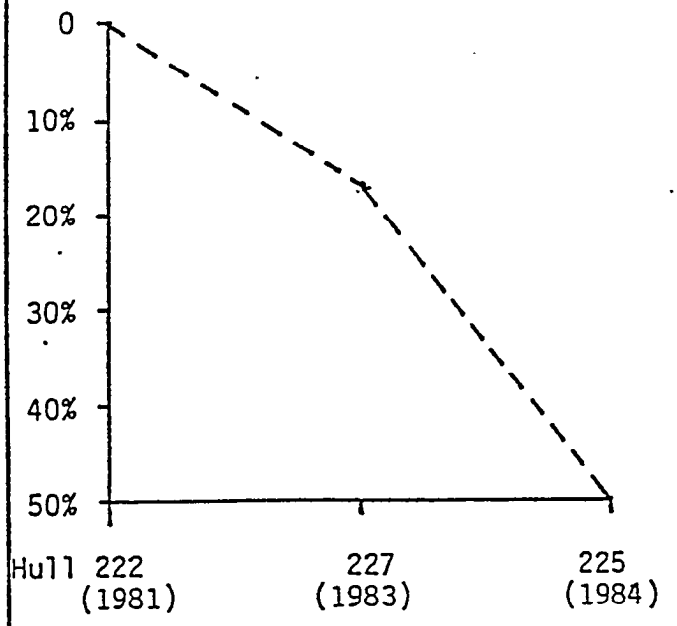
Fire Main Pipe in Superstructure



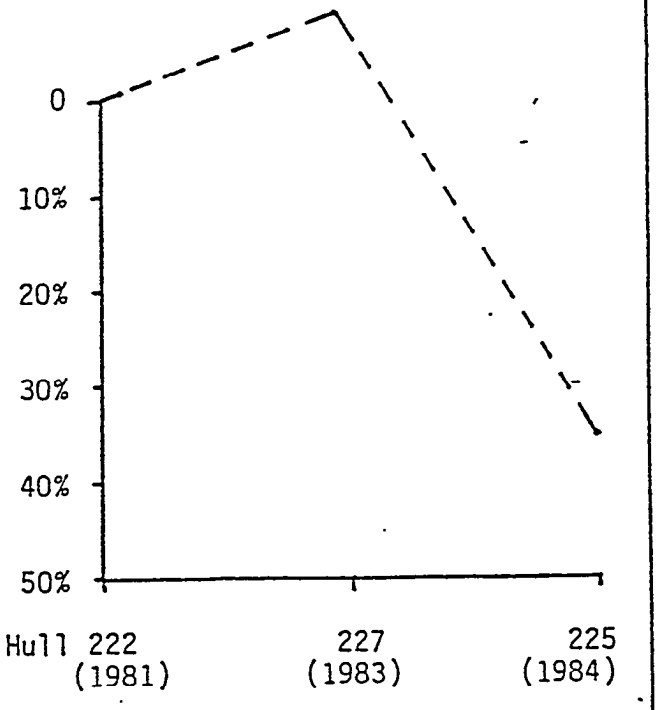
Domestic Pipe Systems in Superstructu

FIG. 10(e)

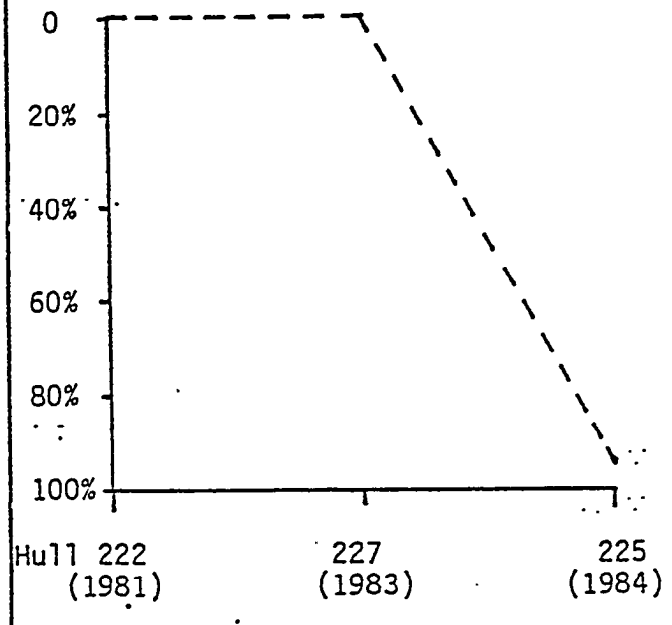
Reduction in manhours following introduction of zone outfitting in superstructure



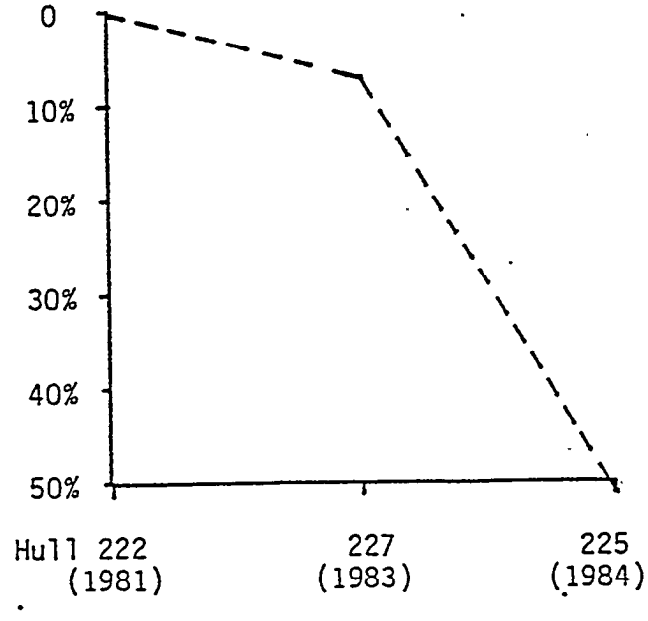
Installation of Sulzer Exhausts



Staging in Casing



Berth Crane Lifts to Casing



Installation of Casing Vent Trunking

FIG. 10(f)

Reductions in Manhours From Construction of Engine Room Casing Module on Hull 225

11. HINDSIGHT AND FORESIGHT

Looking back over the last four years there are a number of different steps which, if taken, would probably have benefitted the yard.

(a) Drawing Offices

The Drawing Offices operate as four separate groups, Steel, Engineering, f-lull Outfitting and Electrical, and although co-operation has improved, we do not have a zone-orientated Drawing Office, under one Technical Manager. The ships constructed during-the period covered by this report were similar but not identical and we have been unable so far to design "standard components" of any complexity which could be used on other ships. The Drawing Office has operated under a full load of work for several years. when a lull in their schedule appears it may be possible to introduce designs for standardization of items such as masts, seats, minor tanks, purifier modules, pump modules, hatch covers, deck cranes etc. The introduction of composite drawings was a major advance and assisted in approaching the ship as a number of zones rather than a number of systems.

We are fortunate in the respect that the vast majority of our ships are Collingwood designed. The result is production orientated to match the facilities of the yard. We believe this is more productive than attempting to work to drawings produced elsewhere by a team of designers unfamiliar with our strengths and weaknesses.

cont'd.....

HINDSIGHT AND FORESIGHT - cont'd.....

(b) Production Department

There have been no changes in organization to match the zone concept. It might have given more impetus to the changes to have appointed a co-ordinator responsible for Zone Outfitting. In practice, the Planning Department filled this role with the co-operation of the Steel, Engineering and Outfit Superintendents. Some departments have been reluctant to move from old methods and Production was slow to force the issue.

The Painters could have carried out more of their work before steel units were erected. Weather is a problem in collingwood during the winter and painting the ship at the outfit stage after launch usually had priority over the ship being erected on the berth - resulting, of course, in a never ending cycle of unpainted units erected on the berth requiring painting later at the outfit stage.....

The electricians-had to be almost forced into the Assembly shops at the beginning of each contract but performed well once they had started. We had to repeat the same procedure when the first units for the next contract were ready.

We realize that in shipbuilding, as in other traditional industries, old habits die hard, and the "new" methods were not forced on the yard overnight. It was explained beforehand what was being attempted and we have been fortunate that the employees recognized the advantages of the changes. The result has been a minimum of labour disruptions or grievances.

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HINDSIGHT AND FORESIGHT - cont'd.....

(c) General

Probably the biggest mistake made in Collingwood was the failure to establish a "Steering Committee" for each contract to set out goals to be achieved in Zone Outfitting. Planning tried to accomplish this by legwork, memos and phone calls.

A formal organization could possibly have achieved more progress.

The yard is now moving into Superstructure Block Outfitting. This advance should have taken place earlier but was delayed due to the failure of a berth crane. Block Outfitting is an important step for the yard as the demand for Great Lakes bulk carriers is slowing down and our future contracts may consist of smaller, more outfit-intensive vessels:

(d) The Future

There is no doubt in anyones' mind in Collingwood that the steps described in this paper were worth taking to improve the productivity in the yard. It is worth pointing out that these changes have been made at very little cost.

Capital investments have been made in the yard during the period in question, but it is fair to say only a very small percentage of the gains achieved in outfitting can be attributed to these investments. The vast majority of capital spent on improvements to facilities have been directed towards steelwork.

cont'd.....

HINDSIGHT AND FORESIGHT - cont'd.....

An atmosphere of "wanting more" is now appearing, outfit trades are fitting additional items on units in Assembly on their own initiative.

On future contracts we will extend the steps taken to date.

We also intend redefining the steel unit structure to match additional crane capacity, the accommodation will probably be erected as multi-deck units after extensive outfitting at the block stage.

Material procurement is still a problem, more material should be ordered from diagrammatics and general arrangements. We need to reexamine the control of material in the yard and the use of pallets.' Victaulic pipe fittings have been tried successfully in one system on a ship now under construction,' the results are promising.

On the same ship a new modular bulkhead and ceiling system is being fitted in the accommodation and is now indicating a labour-saving of approximately 20% over previous systems.

As mentioned earlier, our future contracts are likely to involve vessels with a higher proportion of their cost devoted to outfitting. Zone outfitting will be essential to us to produce vessels at an economic price.

For example we are now building a Canadian Coast Guard Type 1100 Icebreaker, (a navigation aid, light icebreaker).

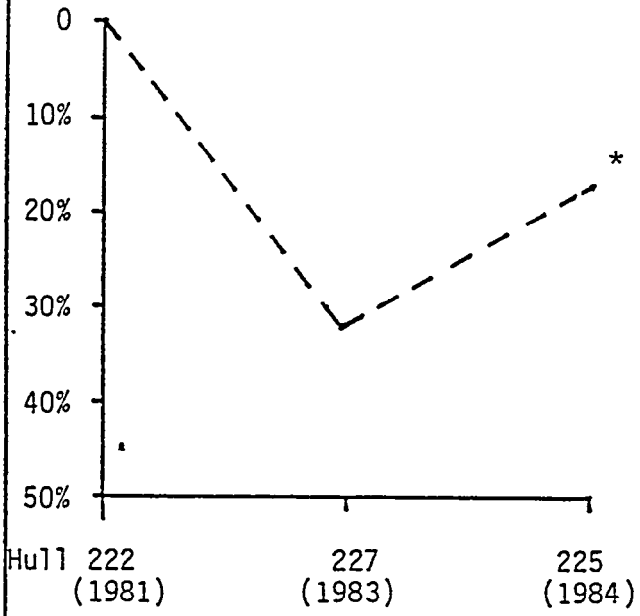
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HINDSIGHT AND FORESIGHT - cont'd.....

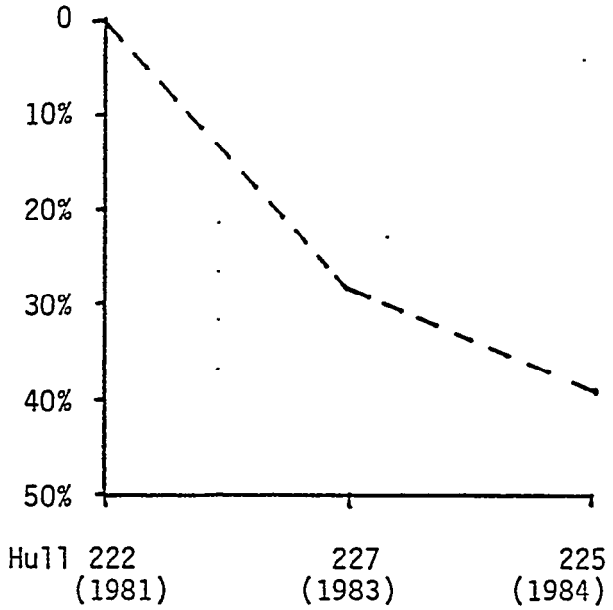
In this vessel, outfitting manhours are approximately the same as steel compared to a bulk carrier where outfitting manhours are approximately 75% of the steel hours.

We are using a 1:16 scale design model for the machinery spaces of this vessel to assist in carrying the concept of zone outfitting from the initial design to delivery.

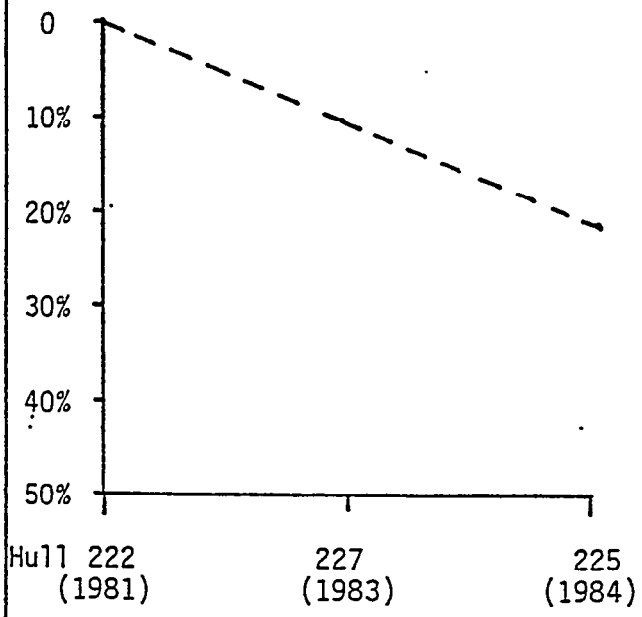
From the Planning Department's viewpoint, it has been a rewarding experience over the past four years to see a shipyard adopt a number of new concepts so readily throughout all levels of the organization, but this is really only the beginning.



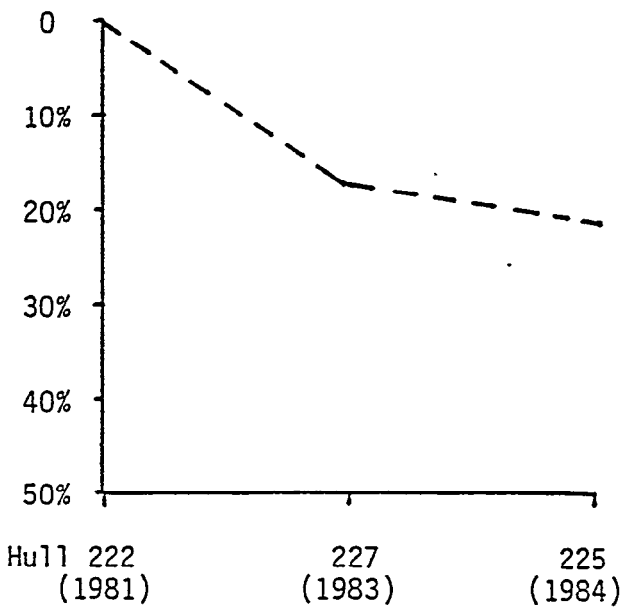
Lower Engine Room Auxiliary Seats
* Additional Seats on this hull



Installation of Lower Engine Room Auxiliaries



Bilge and Ballast Pipe in Engine Room



Fresh and Sea Water Pipe in Engine Room

FIG. 10(c)

Reduction in Lower Engine Room Manhours following introduction of Pump Modules

THE USE OF STATISTICAL METHODS IN DIMENSIONAL PROCESS CONTROL

by

Stephen Krajcsik
Bethlehem Steel Corporation
Sparrows Point Shipyard
Sparrows Point, Maryland

for

NATIONAL SHIPBUILDING RESEARCH PROGRAM
ANNUAL TECHNICAL SYMPOSIUM
September, 1985

NSRP 0226
Page #10

THE USE OF STATISTICAL METHODS IN DIMENSIONAL PROCESS CONTROL

by Stephen Krajcsik

ABSTRACT

In shipbuilding, the stage of construction which lends itself to the most time and cost reduction is unit erection in the basin or on the ways. This requires all units to be complete and accurately assembled in order to eliminate costly rework during and after erection. To achieve this high degree of unit accuracy, we have begun a pilot dimensional control program that has set the guidelines for systematically monitoring each stage of the production process prior to erection. Through the collection and analysis. of data, we can take steps to control each process and insure that we are achieving our desired degree of accuracy. The cumulative effects of "fine tuning" each individual work process will ultimately lead to improvement in the dimensional accuracy of our completed units.

This paper discusses our experience in applying statistical methods in the collection and interpretation of dimensional data on our automatic burning machines. The results obtained and the benefits derived from the pilot program have proved to us that statistical process control, as applied successfully in Japanese shipyards, is a viable method for improving productivity in the shipbuilding industry.

PROGRAM OVERVIEW

The three basic concepts that form the foundation for our pilot program are:

* The application of process lanes.
* The establishment of process standards.
* The development of a statistical database.

1. The application of process lanes.

A process lane is simply the categorization and separation of like kinds of work (1). From a dimensional control viewpoint, a process lane provides repeatable processes. If a process is repeatable, statistics can be used to analyze observed variations from normal performance. Exhibit 1 illustrates the categories of assemblies and separation of work areas that make up our process lanes (2).

2. The establishment of process standards.

For the purposes of our pilot program, we have defined a Process Control Standard as:

> A mutually agreed upon, formally published description of a work process for the purpose of defining certain characteristics of that work process that must be the same (within a specified tolerance) each time the work'process is performed (3).

PROCESS LANE CATEGORIZATION

A. MAIN ASSEMBLY

CATEGORIES	ASSEMBLY AREAS
Category 1 - Flat Panel Units	Panel Shop
2 - Curved Shell Units	11, 12, 13, 14 Tables
3 - Superstructure Units	13, 14 Tables, Dk. House Jig
4 - Fore and Aft Peak Units	12, 13, 14 Tables (Jigs)
5 - Engine Rm. Doublebottom Units	Panel Shop/12, 13, 14 Tables
6 - Special Weldments	Various

B. SUB-ASSEMBLY

CATEGORIES	ASSEMBLY AREAS
Category 1 - Floors	21, 22, 23, 24 Tables
2 - Girders, Webs	21, 22, 23, 24 Tables
3 - Longitudinal Bhds.	21, 22, 23, 24 Tables
4 - Transverse Bhds.	21, 22, 23, 24 Tables
5 - Built-up Beams	21, 22, 23, 24 Tables
6 - Brackets	21, 22, 23, 24 Tables
7 - Bhds. (not produced in panel line)	21, 22, 23, 24 Tables
8 - Special Weldments	Various

C. FABRICATION

CATEGORIES	FABRICATION AREAS
Category 1 - Shell Plates	
A. Straight Line Cut	Exactograph
B. Irregular Shape	#2 A.B.M.
1. Roll	Rolls
2. Roll & Line Heat	Rolls/Furnace Area
3. Press	Press
4. Roll & Blacksmith	Rolls/Furnace Area
2 - Internal Members	
A. Main Plate	#3 & #4 A.B.M.
1. Roll	Rolls
2. Roll & Line Heat	Rolls/Furnace Area
3. Press	Press
4. Roll & Blacksmith	Rolls/Furnace Area
3 - Structural Members	
A. Purchased Shapes	
1. Straight	Shape Layout Area
2. Curved	Frame Bender/Furnace Area
B. Built-up Stiffeners	
1. Straight	Fab Shop
2. Curved	Frame Bender/Furnace Area
C. Angle Cut from Channels	
1. Straight	Shape Travograph
2. Curved	Frame Bender & Travo
D. Flat Bars	
1. Straight	Plate Travograph
2. Curved	Frame Bender/Furnace Area

EXHIBIT 1

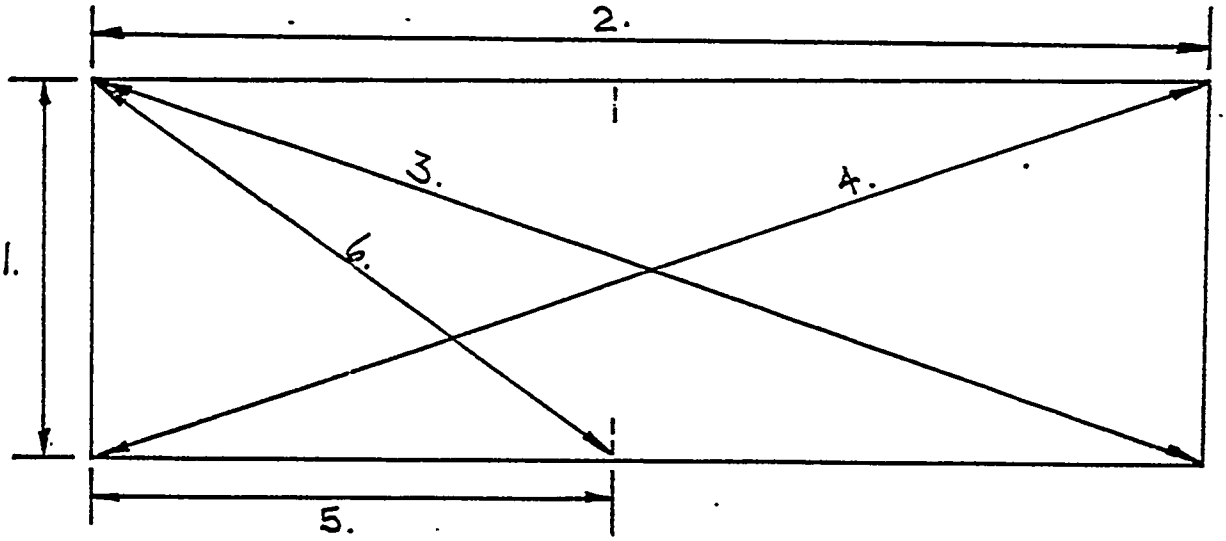
Standard ranges and tolerances were set for each work process after careful consideration of vital dimensions, common shipbuilding practice, and classification society requirements for the finished vessel.

Our process standards will be reviewed and/or revised on a regular basis. They must reflect changes in work processes due to refinements in methods or equipment, changes in the nature of the work being performed at a given time, and changes in owner or classification society requirements. Exhibit 2 illustrates a process control standard for parts fabrication on our No. 3 Automatic Burning Machine (No. 3 ABM).

3. The development of a statistical database.

A statistical database is a quantitative measure of normal work performance at each work station. Once a database is established, it will serve as a permanent record of the process capabilities. Refinements to any process through changes in procedures or equipment can be measured by direct comparison of new performance vs. the database. Also, the compilation of database variables (mean, variance, standard deviation) is a prerequisite for the use of variation merging equations to predict excess and shrinkage allowances for each assembly.

WORK STATION: PARTS FABRICATION	PROCESS CONTROL	APPROVED:
WORK PROCESS: #3 A.B.M.	STANDARD	DATE:



	SCALE: 16th IN.	-3	-2	-1	0	+1	+2	+3	SAMPLE SIZE	EQUIPMENT
1.	WIDTH			X	X	X			6 PL/SHIFT	STEEL TAPE
2.	LENGTH			X	X	X			6 PL/SHIFT	
3.	DIAGONAL			X	X	X			3 PL/SHIFT	
4.	DIAGONAL			X	X	X				
5.	REF. MKS. TO PL EDGE			X	X	X				
6.	DIAGONAL			X	X	X				
					TOLERANCE ± 1/8					
					STANDARD ± 1/16					
				X	X	X				

NOTES:
1. RANDOM SAMPLES TAKEN THROUGHOUT SHIFT. (MACHINE OPERATOR).
2. MEASUREMENT ACCURACY TO NEAREST 16th INCH.
3. NOTIFY SUPERVISION/MAINTENANCE IF TOLERANCE IS EXCEEDED.

EXHBIT 2

PROGRAM RESULTS

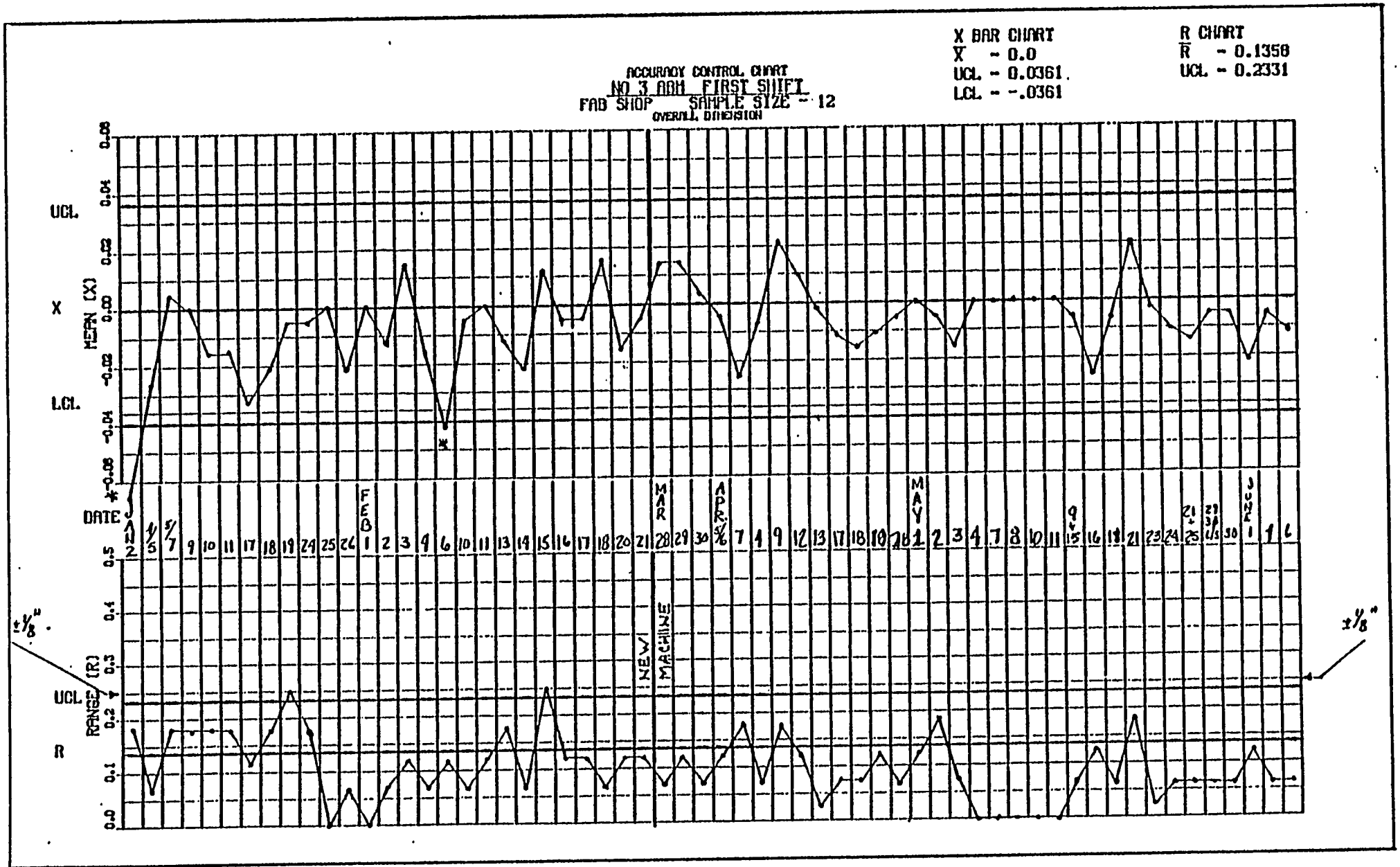
The pilot program consisted of monitoring the performance of two burning machines: The No. 3 ABM, a Linde Model CM-100 n/c plasma arc machine, and the Inside Travograph, a 4 torch optically controlled oxy-fuel machine. The No. 3 ABM was scheduled for extensive overhaul (replacement of drive mechanism from "pinch type" roller to rack & pinion, and replacement of main control console). The Inside Travograph was scheduled to be scrapped and replaced with a new Linde Model CM-100, 12 torch n/c oxy-fuel machine.

The objective of the program was to establish a statistical history of the machines' capabilities prior to the scheduled maintenance project, and provide evidence that the upgraded machines operate within the accuracy limits of our process standards and the machines' purchase specifications.

1. Regular (Daily) Analysis.

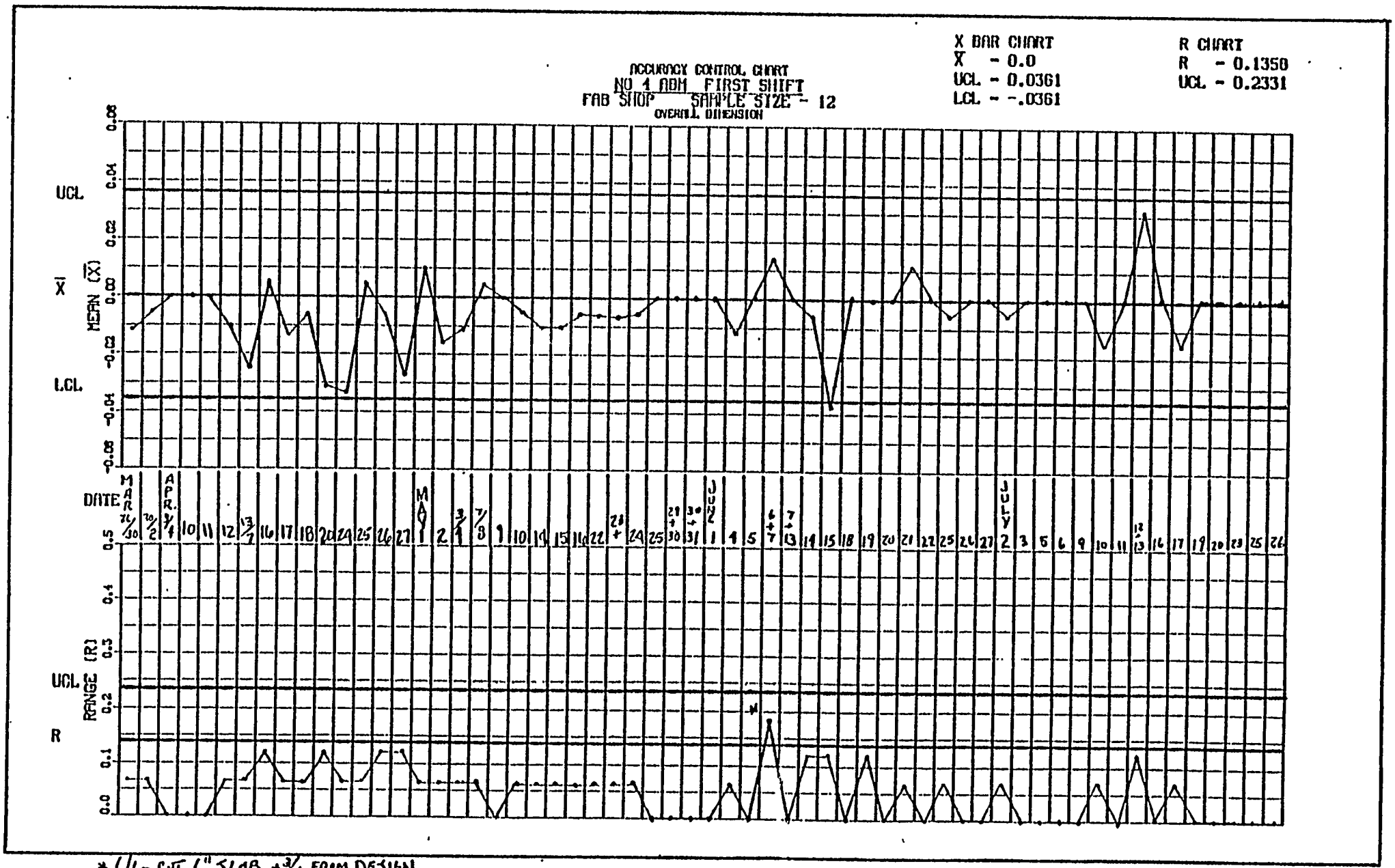
Control of each machine was achieved through the daily collection and evaluation of dimensional data. Machine operators performed daily dimensional checks which were recorded on dimensional control worksheets and used to construct (X,R) control charts (Exhibit 3).

The upper and lower control limits were set to coincide with the values of our process control standards. For example, the limits for overall dimensions of burned pieces (Exhibit 3) represent a 99% probability that the machine is burning within the tolerance limits of 0+1/8 inch.



*Y.B. REPAIR 2/3/84
*Y.B. REPAIR 2/7/84

EXHIBIT 3



* L/L - CUT 6" SLAB +3/16 FROM DESIGN

EXHIBIT 3

The control charts were then used to identify any tendencies or variations in the operation of the machines. If the data indicated fluctuations beyond the control limits, the following options were exercised: (4)

* Complete a more detailed investigation of the data.
* Investigate methods of measurement and instruments used.
* Notify maintenance department for evaluation/repair of machinery.
* Notify planning department for evaluation of changes in assembly procedures.

The daily analysis of the machines resulted in improvements in both the operation and maintenance of each machine. A few interesting items which were either directly or indirectly related to this aspect of the program are:

* Slight variations in the data collected by different shift operators were thought to be caused by differences in measurement methods. After investigation, it was found that manual inputs, particularly kerf settings, were set differently by each operator. A standardized operation chart, listing various manual settings and nozzle/tip sizes vs. plate thickness has since been developed. Subsequently, collected data has been consistent, regardless of the operator.

* Control charts were posted at each machine, providing each operator with an idea of the quality of work he was producing. Since the data indicated that the machines were operating within the pre-established limits, workers in the “customer" areas of sub-assembly and final assembly had more confidence in the dimensional accuracy of the pieces they received.

* Increased awareness in the importance of burning quality resulted in the hiring of a burning consultant to retrain all burners in machine and hand torch techniques. Vendors were consulted with regard to providing better burning equipment and torch tips. Increased use of portable machines and burning templates resulted in on-ship improvements in burning quality.

* Control charts provided a quantitative yardstick for measuring the effectiveness of regular machine maintenance on each machine.

2. Statistical Database

The cumulative collection of data for each burning machine provided a process mean (X), variance (σ^2), and standard deviation (σ). By definition, standard range ($\bar{X}\pm2\sigma$) represents 95% of the variation of a normally distributed set of data, and tolerance range ($\bar{X}\pm3\sigma$) represents 99% of the variation of a normally distributed set of data (5). These values establish the normal work performance for each machine.

Exhibit 4 is a summary of the results obtained on each machine for the variation of overall dimensions from design. The percentages of values within 0±1/16 inch and 0±1/8 inch correspond to the ranges of our process standards.

Based on the results obtained from this program, it can be concluded that the repair and replacement of the burning machines have improved the dimensional accuracy of fabricated pieces leaving the shop (a 13% increase on the No. 3 ABM and a 25% increase on the new No. 4 ABM of pieces fabricated within 0±1/16 of design). Our ability to provide statistical evidence of the machines capabilities has been partially responsible for our recent success in securing non-shipbuilding work for the shop during slack periods.

DIMENSIONAL CONTROL DATA SUMMARY

WORM PROCESS: Parts Fabrication

WORK STATION: No. 3 ABM

CHARACTERISTIC MEASURED; Overall Dimensions (length, width)

SAMPLE SIZE: 12 Measurements/Shift

PROCESS STANDARD: Standard Range: 0±1/16 inch

Tolerance range: 0±1/8 inch

(Machine spec.: 0±1/16 inch in 40 ft.)

PERIOD	AVERAGE	VARIANCE	STD. DEV.	% 0±1/16	% 0±1/8
1	-.0121	.0289	±.0425	84.38	99.51
2.	-.0261	.0364	±.0477	74.27	97.93
3	-.0087	.0397	±.0498	78.35	98.67
4	-.0117	.0307	±.0438	8[illegible].15	99.42
5	-.0343	.0136	±.0292	96.57	99.80
TOT.	-.0135	.0313	±.0442	82.38	99.31

Period 1: 06/24/83 - 07/04/83 (n=346)
Period 2: 09/15/83 - 12/31/83 (n=634) 1st shift
Period 3: 09/15/83 - 12/31/83 (n=588) 2nd shift
Period 4; 01/02/84 - 03/21/84 (n=354)
Period 5: 03/28/84 - 06/30/84 (n=482) Machine overhaul completed

EXHIBIT 4

DIMENSIONAL CONTROL STUDY

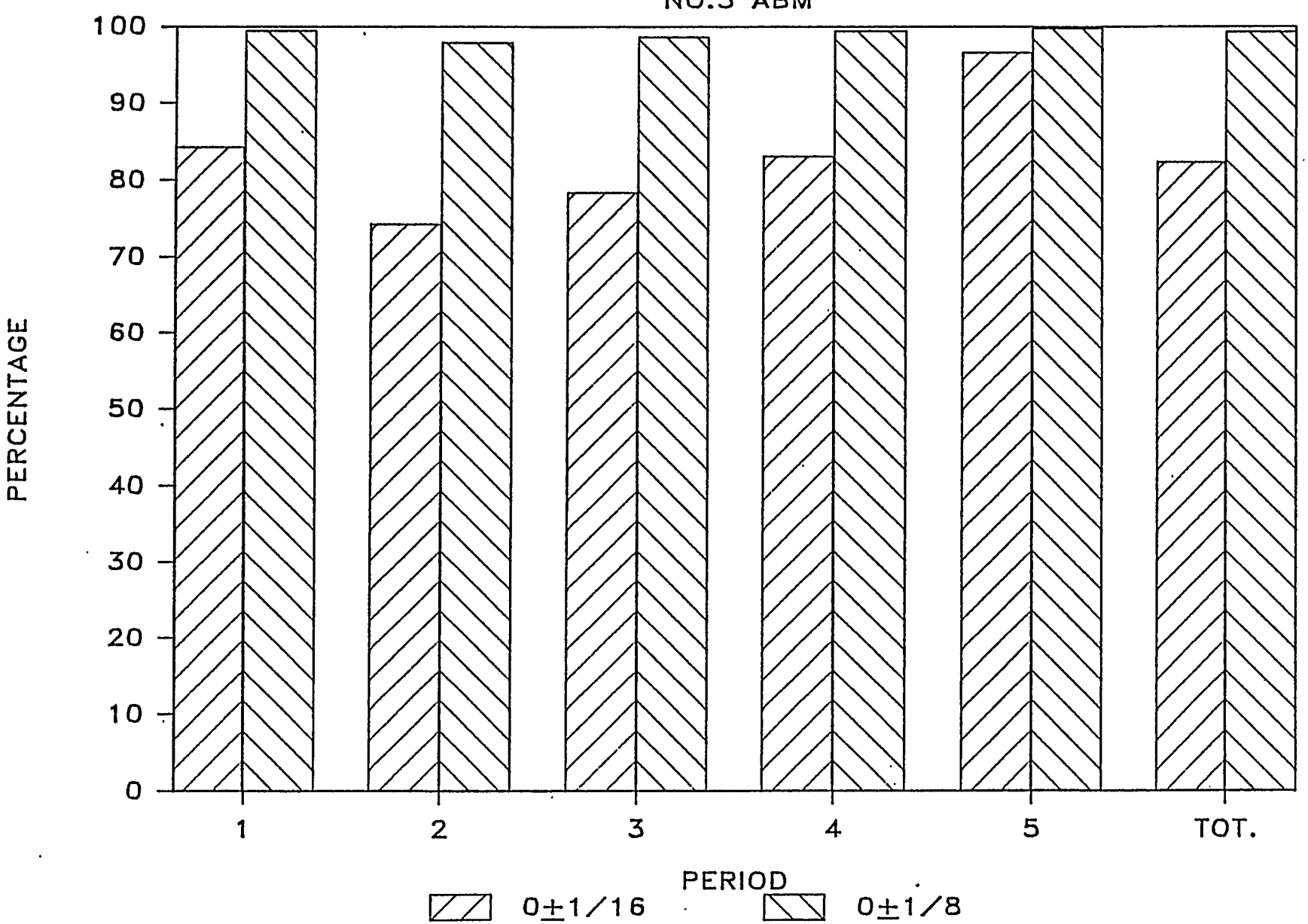


EXHIBIT 4

DIMENSIONAL CONTROL DATA SUMMARY

WORK PROCESS: Parts Fabrication

WORE STATION: Inside Travo/No. 4 ABM

CHARACTERISTIC MEASURED1 Overall Dimensions (length, width)

SAMPLE SIZE; 12 Measurements/Shift

PROCESS STANDARD: Standard Range: 0±1/16 inch

Tolerance range: 0±1/8 inch

(Machine spec.:0±1/16 inch in 40 ft.)

PERIOD	AVERAGE	VARIANCE	STD. DEV.	% 0±1/16	% 0±1/8
1	-.0107	.0423	±.0514	76.60	98.27
2	-.0281	.0630	±.0628	63.39	93.09
3	-.0230	.0430	±.0517	72.69	97.35
4	-.0060	.0019	±.0272	97.53	99.80
TOT.	-.0184	.0412	±.0507	75.30	97.97

Period 1: 06/30/83 - 11/30/83 (n=240
Period 2: 11/15/83 - 12/31/83 (n=514)
Period 3: 01/02/84 - 03/27/84 (n=778)
Period 4: 03/28/84 - 06/30/84 (n=510) New Machine
Period 4: 03/28/84 - 06/30/84 (n=482) Machine overhaul completed

EXHIBIT 4

DIMENSIONAL CONTROL STUDY

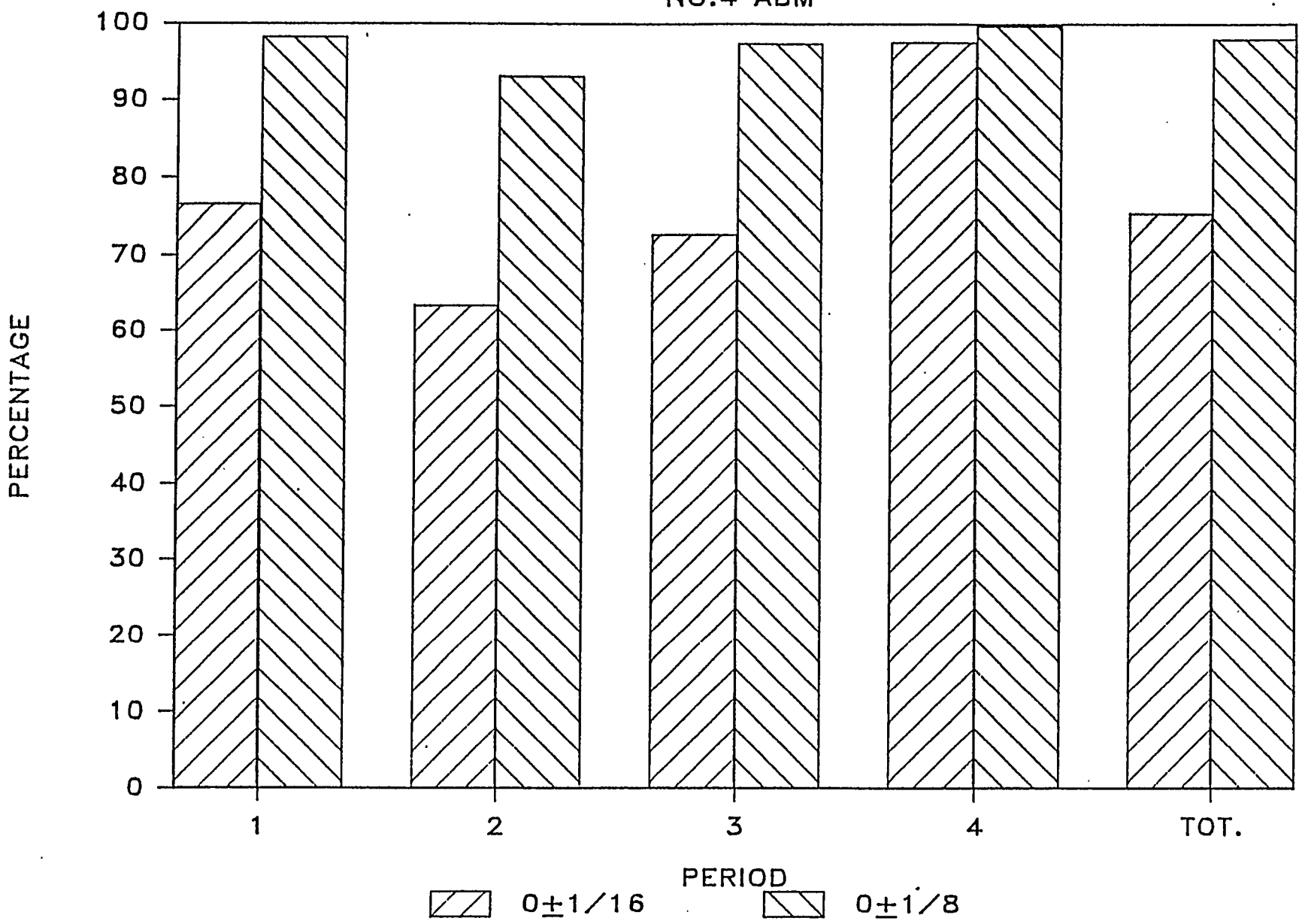


EXHIBIT 4

CONCLUSION

The value of this report does not lie in the numbers presented here, but rather in the methodology of controlling work processes through the collection and interpretation of data. The ability to make sound engineering and management decisions is directly related to the amount, the quality, and the format of the information that is available.

The expansion of a statistical quality control program to all shipyard work processes represents a significant commitment of resources by top management. It also represents a significant change from traditional methods to a more modern shipbuilding approach. The impact of such a change must be realized and accepted throughout all activities within the shipyard.

Japanese quality circles are dependent on everyone, workers included, to regularly and willingly participate in problem solving so as to constantly improve productivity. The possession of such capabilities in shops, is a tremendous competitive edge (6). This type of awareness and participation, as practiced by the Japanese shipbuilder's, can only be obtained through the education and training of each yard's most important resource; its employees.

REFERENCES

1. R.A. Price, "Process Lanes Feasibility Study", U.S. Department of Transportation, Maritime Administration, February 4, 1984, p.2

2. Avondale Shipyards, Inc., Process Lanes and Design Engineering for Zone Outfitting", U.S. Department of Transportation, Maritime Administration, Seminar Proceedings of June 7, 8, 1984.

3. Kevin Gildart, James Burbank, "Feasibility of Shipbuilding Standards - Executive Summary", U.S. Department of Commerce, Maritime Administration, October 1976, p.3

4. L.D. Chirillo, "Process Analysis Via Accuracy Control", U.S. Department of Transportation, Maritime Administration, February 1982, p.23

5. L.D. Chirillo, 'Process Analysis Via Accuracy Control", U.S. Department of Transportation, Maritime Administration, February 1982, p.15

6. L.D. Chirillo, "Testimony Submitted to U.S. House of Representatives Subcommittee on Merchant Marine and Fisheries', June 20, 1984, p.12

LIST OF EXHIBIT CAPTIONS

EXHIBIT 1 PROCESS LANES CATEGORIZATION

EXHIBIT 2 PROCESS CONTROL STANDARD

EXHIBIT 3 CONTROL CHART - NO. 3 ABM

CONTROL CHART - NO. 4 ABM

EXHIBIT 4 DIMENSIONAL CONTROL DATA SUMMARY - NO. 3 ABM

DIMENSIONAL CONTROL DATA SUMMARY - NO. 4 ABM

THEODORE ROOSEVELT (CVN 71)
CONSTRUCTION SCHEDULE COMPRESSION

SNAME SHIP PRODUCTION COMMITTEE
PANEL SP-2, OUTFITTING AND PRODUCTION AIDS

Irving D. Halper
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Introduction

The shipbuilding industry has made significant advances in its use of modernized ship construction techniques and facilities. I am certain that many of the papers being presented at this Symposium will describe those techniques and address the technical advantages that accrue from their use. This paper, in addition to discussing those topics, attempts to examine the environment in which improvements in ship construction can occur and looks at the type of planning that must be done to ensure benefits are realized. The Navy is now the major customer of the U.S. shipbuilding industry, and even with the increased emphasis on competitive procurement, by necessity, contracts for a significant amount of sole source ship construction will exist due to technical or facility constraints. For these contracts, as well as many others, the shipbuilder has a limited incentive to accept the increases in risk inherent in changing his business strategy and existing industrial processes. The Navy has recognized this problem and I will now attempt to describe the successful effort to change this environment for aircraft carrier construction.

Program Background

In 1979 the Navy started the detail planning for the acquisition of THEODORE ROOSEVELT (CVN 71), which is the fourth ship of

the NIMITZ class of nuclear aircraft carriers. Since CVN 71 was a repeat design, the planned and actual construction schedules for the earlier ships were closely examined to determine if improvements were possible and, if so, what steps should be taken to ensure that an optimum schedule was achieved. An optimum schedule, in this instance, is one that achieves the earliest possible ship delivery at the lowest possible cost to the taxpayer. This would ensure minimum escalation and "parking" or facility cost and should result in significant total cost savings. In addition to the direct monetary saving which might be realized by this optimized schedule, improved shipbuilder performance would enhance the opportunity for renewed public support of the defense expenditures that were being advocated for major Navy programs in the 1980's. Earlier delivery of CVN 71 would also be very important strategically, providing for a more rapid counter to the Soviet naval buildup, quicker reconstitution of U.S. military presence around the world, additional flexibility in the overhaul and refueling of existing carriers, and earlier availability of improved ship construction resources at Newport News Shipbuilding (NNS). The plans for a Ship Life Extension Program (SLEP) on CV 59 class carriers would also be enhanced by the availabilty of CVN 71 since the need for a Navy presence in the Indian Ocean was severely straining our strength in the western Pacific.

Prior Schedule Experience

At this time it was recognized that, from a contractual standpoint, achieving the optimized schedule would be difficult since NNS was the sole source shipyard for NIMITZ class carriers and its prior experience would tend to make them conservative unless suitable incentives could be provided. That experience (in 1979) can be summarized as follows:

Shin	Award to Delivery (Months)
USS NIMITZ (CVN 68)	97 (Actual)
USS DWIGHT D.EISENHOWER (CVN 69)	93 (Actual)
USS CARL VINSON (CVN 70)	95.5 (Predicted)

CVN 68-70 were constructed by NNS in its South Yard, using a 310 ton capacity gantry crane, for structural sub-assembly erection and machinery lifts. This crane, which at the time was the largest in this country, serviced Shipways 10 and 11 where all three ships were erected. In 1973, construction was started on a new shipyard for commercial work. This was located on filled land just north of the existing facility and was completed in 1976. The new facility consisted of a building basin (Shipway 12), a subassembly area adjacent to the building basin which was sewed

by 60 and 200 ton cranes, a 900 ton gantry crane spanning both the building basin and the subassembly area and a large steel production building containing a panel shop, several steel assembly areas, two outfitting berths, and cutting and forming equipment, all supported by its own steel storage and surface preparation complex. This new facility, which was built for construction of commercial LNG and ULCC ships, offered some obvious advantages for construction of a comparably sized nuclear carrier. The use of this facility, in light of the uncertainties of the domestic commercial shipbuilding market, was studied by NNs and its potential advantages evaluated. Based on this evaluation of historical data NNS proposed a 96 month period from contract award to ship delivery for CVN 71.

Schedule Studies

During this time the Navy was also studying internal schedule proposals ranging from 60 to 96 months in order to determine what economic benefits could be achieved, what long lead time material would have to be purchased and what work arounds or other techniques might be necessary if a shorter construction period were to be achieved. Other studies examined manpower limitations, the potential for farmout of all or part of the structural

subassemblies, the NNS business environment and the negotiation strategies and format for introduction of an early delivery incentive. A number of conclusions were reached early in this study process:

* The use of farmout for substantial quantities of structural subassembly fabrication was disruptive and not cost effective.

* The time required by the appropriation process to obtain appropiate funds for long lead time material precluded any schedule shorter than 74-77 months from award of the long lead time contract to ship delivery (even this schedule required work-around for some critical machinery components).

* It would probably not be feasible to negotiate an early delivery incentive, or a significantly earlier delivery than that proposed by NNS, until future NNS workload considerations were solidified.

Based on these conclusions it was determined that Navy efforts should be concentrated on enabling the feasibility of a 77 month

building schedule. The initial step was the issuance of the long lead time material procurement and engineering contract between NNS and the Navy on May 5, 1980 in which a planning date of October 1986 for ship delivery was specified. The long lead time material contract required that, where possible, procurements should support the October 1986 date despite the ship construction contract proposal for a 91 month schedule(December 1987 ship delivery) proposed by NNS in July 1980. This involved expediting, and potentially storing, approximately 150' major machinery and material purchase orders being placed by NNS and a comparable number of GFM procurements. Considerable financial risk was involved, but the potential cost savings of earlier ship delivery made that risk justifiable, and the cost of storing material would be offset by savings resulting from early order placement.

Providing Incentives

A definitized contract was executed on September 30, 1980 that specified a September 1987 ship delivery date. On March 4,198l a contract modification to add a complex passive protection system to the ship was bilaterally negotiated. This contract modification further complicated the schedule issue by adding significantly to both the scope of work and technical risk of early structural

erection and resulted in a five month addition to the contract ship delivery schedule.

Throughout this time both the Navy and NNS continued to expedite material deliveries in order to support an October 1986 ship delivery and studies continued to address its feasibility. As the Navy's confidence in GFE and CFE deliveries increased the prospects for a shorter construction period improved. The potential cost savings being projected for a 1986 ship delivery were clearly sufficient to support the offering of additional incentives. The Navy estimated that fixed costs alone during a fourteen month schedule reduction would amount to $ 42 million, and savings from avoiding inflation increases during that period could amount to over $ 50 million as well. What the Navy and the shipbuilder needed to make the shared committment was an incentive to balance the technical risks of schedule compression with the cost savings potential to the Navy and profit increases for the shipbuilder. The Navy held all risks for escalation costs under the contract terms. The shipbuilder and the Navy would share other cost savings (or growth) according to incentive provisions of the contract. The shipbuilder had to assess the value of his share of the cost savings against the schedule risks and facility committment required to attain the earlier schedule. The major

break came about when a combination of business factors provided the incentive to NNS to accept the risks associated with schedule compression. These factors included:

* The absence of commercial workload for the new North yard. This permitted utilization of Shipway 12 with its associated sub-assembly area and 900 ton gantry crane, as well as the new steel fabrication shop, for aircraft carrier construction.

* The potential for series production of CVN's resulting from Congressional consideration of a proposed two ship fully funded program for construction of CVN 72 and 73, which would provide a stable workload base for many years to come. There was additional value to compressing the CVN 71 schedule, since CVN 72 and 73 escalation costs would be significantly reduced by an earlier start in sequence with CVN 71 and these cost savings enhanced the possibility of Congressional approval of the two ship program.

* An Incentive for Early Delivery clause was signed on December 3, 1981 which provided for payment of an *additional profit of $50,000 per day, to a maximum of

> $21,000,000 for a 14 month earlier delivery, if the shipbuilder could achieve schedule compression. This was to be in addition to the share line savings, if any, that would be split under the terms of the Fixed Price Incentive Fee (FPIF) construction contract. The Navy's saving would exceed the maximum amount of the incentive payment, realizing a saving to the taxpayer, in addition to earlier delivery of the ship. And, if earlier delivery were not achieved, 'the basic contract terms would prevail, with no incentive paid. In this combination of results, the incentive clause established the boundaries of risk and reward for both the Navy and the shipbuilder and formed the basis for the sustained committment needed to make the goal a reality.

This background information is provided in order to make a crucial point. The manufacturing improvements that are possible, and which will be described in this paper, will not generally be applied unless there is recognition of the fact that both the owner and builder must have an incentive for their use, and that extensive long range planning must be done to determine their most economic application and support that application with early

material procurement. An additional factor that must be considered is the stability of the construction baseline. Extensive advance planning is useless if the baseline design is subject to extensive change. The customer must decide what he wants early in the game and then stick to it. Changes are always disruptive, but they can be much more disruptive if the shipbuilder has done extensive planning for on block outfitting and work grouping. The CVN's are a mature program that has been well defined by the experience with the earlier ships of the class and the Navy has been actively resisting the "newer is better" syndrome. by severely limiting changes.

Construction Methods

The superlift ability of the 900 ton gantry permitted construction of much larger subassemblies in the steel fabrication shop and platen area The shipbuilder made extensive use of Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) to plan subassembly module sizes, cut steel and provide control over the manufacturing process in order to achieve the tolerances necessary for orderly assembly. These subassemblies were heavily preoutfitted on block and in many instances were virtually complete when lifted into the building dock. Inner bottom sections

were piped out and painted and the rate of tonnage buildup in the dock shown in the following chart reflects the impact of this preoutfitting as well as the effect of the productivity improvements resulting from efficient on block contruction. With the increase in the amount of work being done on the platen NNs was able to significantly increase the percentage of down hand and automatic welding, with concommitant reductions in skill level requirements and weld reject rates. Although statistical evidence is not yet available, the improvement in' the work environment should improve product quality and worker safety. In support of the early outfitting- the Navy agreed to a two tier system of delivery dates for GFM. In addition to the Shipbuilder Desired Dates (SDD's) agreed to by the contract a series of Preferred Dates (PSDD's) were established for early delivery of material to permit the maximum degree of preoutfitting. These dates were provided by NNS to the Navy very early in the process so that the response provided could be incorporated into the planning process. Wherever possible, the Navy met the PSDD and, when it could not, it provided the best possible projections so that non-disruptive work-arounds could be developed.

Effect of Improved Methods

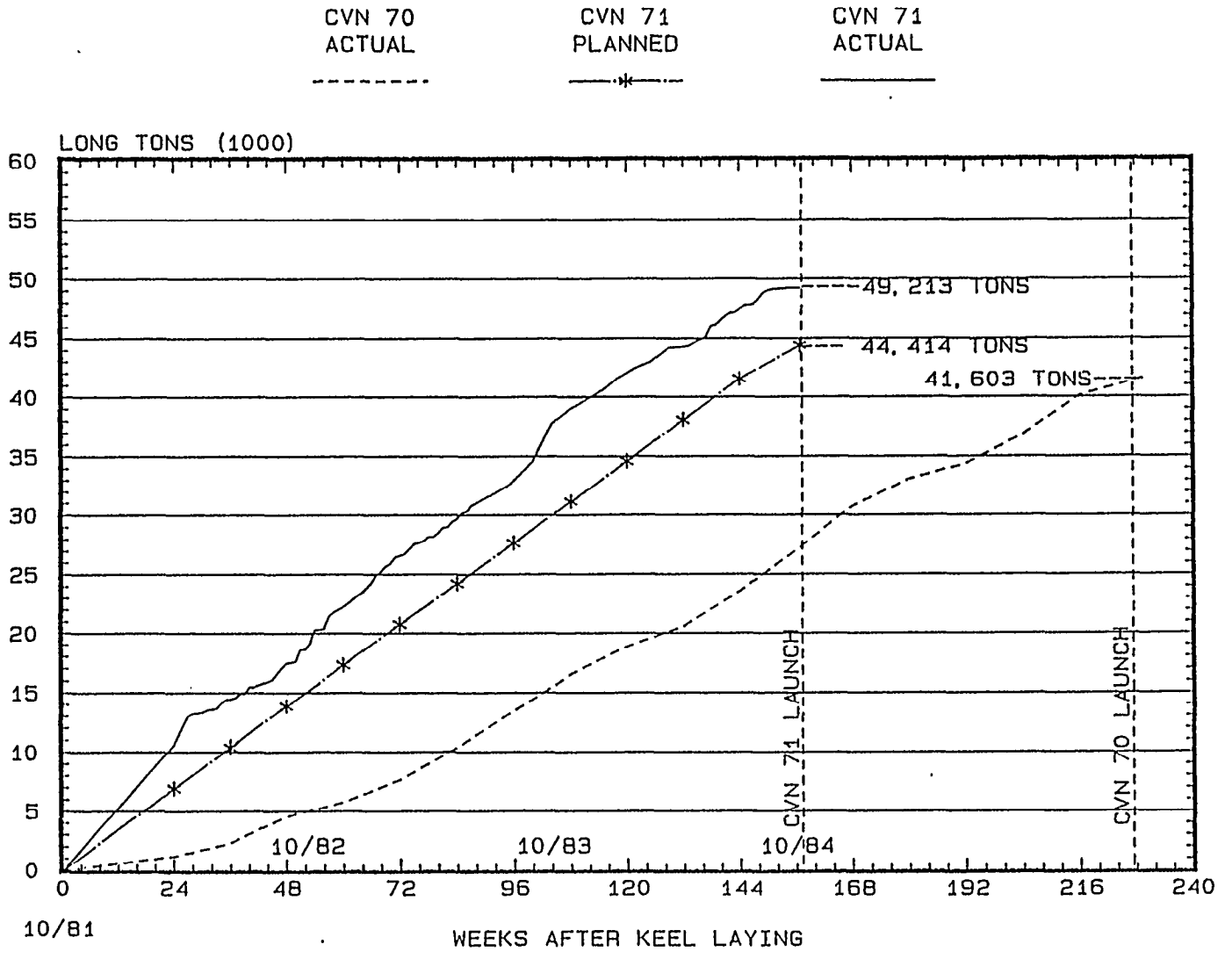
On the basis of the procurement planning accomplished and incentives provided NNS issued a key event schedule on January 8, 1982 that established September 1986 as a "work-to" delivery date and December 29, 1986 as a contract required delivery date. That schedule reflects the advantages of the modern steel erection facilities and superlift capabilities of the North yard and shows significant time savings in both the contract award to keel laying and keel to launch periods where prefabrication and rapid steel erection will provide maximum benefit. The following Table compares the schedule with that of CVN 70. It is worth noting that the launch to delivery period of a complex combatant ship is generally controlled by system testing and is not subject to similar schedule compression.

Shin	Award	Keel	Launch	Delivery
CVN 70	4/05/74	10/11/75	3/15/80	2/26/82
CVN 71	9/30/80	10/31/81	12/01/84	12/29/86

CVN 71 was launched on 28 October 1984, 16 months ahead of the original schedule and, as a comparison of the tonnage at launch

CVN 71 VS CVN 70 TONS OF SHIP IN DRY DOCK

DATA AS OF 27 OCTOBER 1984 (WEEK 157)



will show, much more complete. The extent of the change from building dock to platen construction can be seen from the fact that only approximately 160 modules were used to erect the entire CVN 71 structure. By comparison, a single typical innerbottom section on CVN 70 that required 58 subassemblies was assembled from only 12 subasemblies on CVN 71. It is still too early to fully assess the impact of these changes in the CVN construction process on issues other than schedule, where it is apparent that major improvements have been made and significant taxpayer savings will result. Productivity should be improved, particularly as improved familiarity with the processes impacts on CVN 72 and 73. One intangible fringe benefit has been the experience of seeing some rather spectacular module lifts, some examples of which are provided by the following photos, which show the keel laying, bow section lift and the entire island structure being lifted as a single module.

Conclusions

Much has been accomplished by this cooperative Navy/NNS effort and much more needs to be accomplished. There should be recognition of the need for improved planning in this area from inception of ship concept definition so that contract designs

consider the needs of the new processes available and financial and contractual planning support the technical path chosen. Incentives must be provided and a stable workload attained. The potential benefits to the American taxpayer and shipbuilding industry profitability are enormous. That much more can be done can be seen by looking at the progress being made on ABRAHAM LINCOLN (CVN 72). Its keel was laid in Shipway 12 on November 3, 1984 (5 days after the CVN 71 was launched) and 16 weeks later there were 10939 tons of ship erected in the shipway and massive amounts of subassembly work complete on the platens. By comparison, at this same point in time on CVN 70 and 71 we have estimated that there were 801 and 7818 tons of ship respectively in the shipway. There are parallel gains waiting to be recognized and achieved in other programs if the Navy and the shipbuilding industry strive together to define and achieve them.

PANEL SP-4

DESIGN/PRODUCTION INTEGRATION

F. Baxter Barham
Newport News Shipbuilding

Chairman

Overview of Panel SP-4, Design Production Integration 1985

by

F. Baxter Barham, Jr.

ABSTRACT

Panel SP-4 is seeking ways to assist U.S. Shipbuilding attain and maintain a worldwide competitive position in Time-Cost-Quality. The work of the panel addresses the detail design and planning efforts, integration of those efforts into the production process and the tools involved.

During the past year the panel pursued its goal through the publication of a report on "Software Tools for Shipbuilding Productivity", completing work on a "Design for Production Manual" to be published this quarter and the continuation of efforts on systems of classification and coding and computer aided process planning suitable for the shipbuilding environment. In addition, work has just begun on five new projects involving a broad spectrum of shipyard disciplines. Also, another year's work has been laid out involving four shipyards and two universities. Finally, the panel is establishing interfaces and developing a program on Navy-Industry computerization intended to address the findings and recommendations in the National Research Council's report, "Toward More Productive Naval Shipbuilding".

This report (or manual) is submitted pursuant to a research and development contract without any warranties, expressed or implied. ANY POSSIBLE IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR PURPOSE ARE SPECIALLY DISCLAIMED.

INTRODUCTION

This overview of Panel SP-4 is intended to provide a report of the panel's work over the past year. It will begin with a brief statement regarding the panel's philosphy and purpose (BACKGROUND) in order to provide a baseline against which progress may be measured. The work done during the past year will then be presented under the following headings:

PROJECTS COMPLETED

PROJECTS UNDERWAY

PROJECTS FOR THE FUTURE

PLANNING

All projects listed under the categories noted above have been approved by the SNAME Ship Production Committee (SPC) and those shown as completed or underway have been funded via a Maritime Administration cost sharing contract with Newport News Shipbuilding. Each of these projects (those completed or underway) have been subcontracted by Newport News Shipbuilding to the project sponsor noted. Projects for the future are a part of the panel's program proposed for fiscal year 1985 which has been submitted to the Maritime Administration for funding. Funding is expected this month.

The section headed PLANNING is devoted to SP-4's involvement in preparations to enter the most important and necessary area of cooperative research and development that we face today; Navy-Industry Computerization. The challenge has been laid out in the National Research Council's report "Toward More Productive Naval Shipbuilding" and SP-4 has been working with the SPC, the Ship Design Committee and the Navy to formulate a response.

BACKGROUND

Panel SP-4, Design Production Integration, was established by the Society of Naval Architects and Marine Engineers' Ship Production Committee in April 1981 and its program was first funded via a MarAd contract with Newport News Shipbuilding on July 30, 1982. While Newport News continues to sponsor the panel, the panel's work truly reflects industry wide input and participation. Project selection involves the entire panel membership which represents,

13 Shipyards
4 Universities
3 Design Agents
4 Government Offices
1 Non-profit Research Institute

Shipyards represented by the SP-4 membership have the capability to build, overhaul or repair any ship the customer might want from wood hulls to huge tankers to the most sophisticated warships afloat.

It should be noted that the program developed by this broad industry representation has resulted in projects worked, being worked or scheduled to be worked in the coming year, by the following mix of organizations:

Avondale Shipyards, Inc.
Bath Iron Works Corporation
Bethlehem Steel Corp. - Sparrows Point Yard
Ingalls Shipbuilding Division
Newport News Shipbuilding
Todd Pacific Shipyards - Los Angeles
Todd Pacific Shipyards - Seattle
A University and Shipyard to be determined

All projects will be required to produce generic results which will be documented and the documentation given wide distribution for the use and benefit of the entire U.S. Shipbuilding industry.

The diverse group described above, which is panel SP-4, does have a common purpose. Panel SP-4 is seeking ways to assist U.S. Shipbuilding attain and maintain a worldwide competitive position in Time-Cost-Quality. Its contribution involves the interaction of design and production personnel and, as seen above, representatives of owners (Navy), government agencies, design agents, universities and shipyards. Also, its contribution is through the realization that:

- Design is the first step in, and an integral part of, the production process.
- Integration of the production process involves the application of computer technology to the design and manufacturing disciplines.
- Products must be designed for ease of construction as well as superior performance.

Simply stated, the work of the panel addresses the ship detail design and planning efforts, integration of those efforts into the production process and the tools involved.

The areas of concern, the premise on which the panel is founded, and the panel's approach to its task has led the panel to accomplish much through its program as outlined below.

PROJECTS COMPLETED

Software Tools for Shipbuilding Productivity

This project was worked by Grumman Data System Corporation under subcontract to Newport News Shipbuilding. The following quote from the executive summary of the project report provides insight into how the project was worked as well as the subject matter covered.

"The objectives of this study are to define and identify software tools, and to impart to the shipbuilding community the knowledge to use them to aid in the design/production integration of the shipbuilding process. The approach taken in this study has been to:

- Research, review and define the CAD/CAM integration process
- Develop selected scenarios of modern CAD/CAM integration methods
- Isolate and research software aspects of CAD/CAM scenarios; select and list application areas for software tools to (potentially) increase productivity for the integration process defined
- On-site visits to shipyards to review prepared CAD/CAM scenarios and software tools to define applicability of technologies, need for changes and knowledge-level of potential users
- Collect, reduce and review data from on-sites visits
- Create a scenario adapted to the real-world of shipbuilding; identify critical software needs and select useful software tools
- Select a shipbuilding scenario and determine software needs to actually generate the integrated system; outline a means to calculate potential savings through the use of software tools.

The material presented is ordered as outlined, and is followed by a catalog of software tools, and a recommended means of distributing results to the shipbuilding community. A glossary of acronyms is also included...

This report has as its focus, the identification of CAD/CAM integration requirements and software tasks required to support them. The categorization of these software tasks into logical steps amendable to increased productivity by application of specific software tools is the end product of benefit to the shipbuilding community. Tools and the knowledge to use them, in this case for increased CAD/CAM

software productivity in the shipbuilding design/production process, is the theme of this report."

The final report was distributed January 8, 1985, is now in its second printing and has been distributed to over 120 persons across the United States and Canada. A limited number of copies are still available from F. B. Barham, SP-4 Chairman, Newport News Shipbuilding.

PROJECTS UNDERWAY

Design For Production Manual

This project is sponsored by Bethlehem Steel Corporation, Sparrows Point Yard with the cooperation of J. J. Henry Co., Inc. and utilizing the consulting services of A&P Appledore Ltd. of the United Kingdom. The project is being worked in three phases as follows:

I Definition of Requirements

II Production of the Manual

III Dissemination to the Industry

Phase I is complete and we are nearing the end of Phase II. The manual, which will be published this quarter, will be in three volumes intended for use by implementing managers, design engineers, planners and production and industrial engineers. The first volume will cover Concepts, the second will cover details of Design Production Integration and the final volume application of Production Engineering.

The manual outlines and explains the basic concepts of design for production, translates these concepts into practical applications and provides implementation guidelines. However, the manual is not intended to be a stand alone cure all for U.S. Shipbuilding. It is viewed by the panel as a developing tool both in the sense that it will act as a catalyst in the thinking process necessary to develop and implement design for production concepts and also it will be dynamic and continuously expanding in detail and scope in logical stages based on the individual needs of the shipyards that use it.

The manual will be provided in loose leaf covers to accommodate supplementary data developed by the user, and perhaps reports from follow-on SP-4 projects.

Product Work Classification and Coding System

Todd Pacific Shipyards Corporation, Seattle Division is the sponsor of this project. We are now in the last phase of a two phase project scheduled for completion by the end of June 1986.

This project is intended to investigate and provide a tool to increase productivity in U.S. Shipyards through the application of group technology principles to the unique features of shipbuilding. The unique features include:

- Hull structural fabrication and assembly
- Outfitting
- Surface preparation and painting.

The tool to be investigated and provided is a classification and coding system that will be computer compatible, usable with a computer aided process planning system and which will accommodate the application of group technology concepts to the shipbuilding features noted above.

The project has developed an attribute listing and a coding scheme which is now under review. When review is complete, portion(s) of an FFG 7, Class Frigate will be broken down into hull block construction, zone outfitting and zone painting work packages. The classification and coding system will be applied to the work packages to insure that all work involved in producing the test portion(s) of the ship can be coded by the system.

A two part evaluation will be made of the test results. First, a survey will be made to determine what percentage of the work was classified by the system. Work not classified by the system will be examined to discover system deficiencies.

Secondly, Todd, Los Angeles personnel will use the system to classify the work packages and a group technology consultant will evaluate the systems ease of use.

At the conclusion of this effort the coding and classification system will be modified to correct shortcomings discovered.

The final project report will completely describe the system development and application, explore its use with group technology and touch on related subjects such as computer aided process planning and cost collecting. The report will also include a glossary of terms and a literature file listing resource documents.

Computer Aided Process Planning System

This project is sponsored by Bath Iron Works and is scheduled for completion by the end of the second quarter, 1986.

Process planning is the selecting and sequencing of manufacturing processes and resources. When applied to shipbuilding, the process planning function is complicated by the size of the task, the complexity of the product and the mix of processes. This project will attempt to develop definitions of interim products and manufacturing processes to the point that the project can then select and demonstrate the application of a computer aided process planning system (CAPP) for shipbuilding. Such a system will increase the speed, repeatability and accuracy of the planning function as well as facilitate the planning required to obtain the advantages of group technology in shipbuilding.

The project's scope includes the evaluation of existing commercially available CAPP systems for suitability in the shipbuilding environment. If a particular system is found suitable, it will be tested at Bath Iron Works and a recommendation on its use will be made based on the test results. In event no suitable system in found, phase II of the project will develop a Shipbuilding CAPP System Specification suitable for obtaining fixed price bids for required software and hardware. The project sponsor will circulate any specification so developed to other interested shipbuilders prior to publication.

Close liaison has been established between the CAPP project and the classification and coding project previously outlined. This is an example of a case where cooperative research can yield synergistic results.

Required Content and Format of Engineering Documentation

This project is sponsored by Avondale Shipyards, Inc. and has just begun. Completion is estimated to be by the end of the third quarter, 1986.

Historically, drawings provided to production personnel have been system-level drawings containing all the information needed by all personnel within the shipyard, as well as the ship's operators. The format has been large, rolled or folded drawings.

Today the trend is to provide drawings, material lists, and other documentation which contains only the information needed by personnel at a specific point of construction. In some cases, in the use of numerically controlled machines, certain types of drawings or information may be eliminated or satisfied by tapes or direct computer input to the machine operators. Booklet-type drawings are being implemented in some applications and may be suitable for others. Some information may be better transmitted and read on computer tubes than on paper copy.

The project task group is developing an approach to be used by participating shipyards in assessing the specific information needs at each stage of the production process and in identifying the optimal technique for providing that information. This methodology will be tested by application at each of the participating shipyards. A report will then be prepared by the 'task group, which will be usable by other shipyards in carrying out similar studies.

Information Flow Requirements for Design/Procurement Processes

This project is sponsored by Ingalls Shipbuilding Division. Completion is estimated to be during the second quarter of 1986.

In this project we intended to identify and investigate the controlling and interfacing data needed by the engineering and procurement organizations and develop a system of data acquisition and exchange designed to allow the shipyard to perform the design and procurement functions more nearly concurrently in lieu of sequentially.

Data required by the engineering and procurement organizations will be identified, the point in time that the data is required will be established, and the extent of detail will be determined. Support requirements (spares, training, etc.) will be considered. Flow charts will be used to aid in developing the time phasing aspects of data acquisition. Vendors will be queried so as to use their input to the design/procurement process evaluation. Use of computer data transfer will be investigated.

A formal report including flow charts, dependency networks, problem discussions and recommended methods will be published upon completion of the project.

Interface Impacts - System to Zone Transition

This project is sponsored by Todd Pacific Shipyards, Los Angeles, and is scheduled for completion by the middle of 1986.

Here we have the opportunity to study two Naval combatants of the same class, built at the same shipyard; one by the system method and one by the zone method; and identify the impacts of the transition on the shipyard and its systems and functional areas.

Todd has formulated a well rounded team of engineers, planners and production management personnel suited to thoroughly analyze and document the before and after conditions. The team has been directed to look objectively at the process of ship construction using a recent FFG 7 Class Frigate as a case study. The team is to identify the impacts of

changes on overall productivity as well as determine the sources of problems that stemmed from advanced outfitting. It is also to recommend actions that will prevent the problems identified and which will result in cost reductions.

The Todd team will approach its work as outlined in the four following tasks:

Task 1 Break down original systems oriented design drawing to show:

- Zone/Workstation assignments
- Zone Material Requirements
- zone Estimated Normalized Manhours
- Normalized Cost by Blocks, rather than by system

Task 2 Describe the cost effective ship construction measures used.

- Drawing organization by zone
- Measurement of physical production throughout

  Work Stations
  Process Lanes
  Process analysis by throughout to develop optimized work station loading, departmental and shop floor methods.

- Scheduling examples of assembly, outfit and erection
- Modular construction work orders
- Sequencing outfitting from different crafts
- Material Requisitioning procedures
- Isometric sketches from CAD/CAM system
- Quality Assurance

  Statistical control

- Kitting/Palletizing of material

Task 3 Determine the impacts of zone outfitting methods on production engineering and production processes.

Task 4 Produce computer graphics models of each hull block studied, using different levels (overlay style) for each subsystem. (i.e. structure, piping, ventilation, etc.) Show use of graphics to assist in interference control and outfit sequencing.

Develop a System for Specification Driven Pipe Arrangement Drawings and Pipe Details

This project is being sponsored by Ingalls Shipbuilding Division and is scheduled to be completed during the second quarter of 1986.

This project is to develop the architecture for a CAD system which will produce piping arrangement and detail drawings conforming to the correct material specifications and diagram configuration. CAD technology and an appropriate data base will be used to discipline and insure consistency between piping system drawings and, system diagram configurations and material specifications, thus reducing errors in piping design as developed from contract requirements.

The developed system will be tested using Ingalls' inhouse CAD systems and data for ships currently under contract there. Two piping systems will be used for test purposes; one an inter-compartment system such as the firemain system and one a system localized within one compartment or construction zone.

At least two turn key CAD systems will be investigated to insure that the architecture has been formulated to be independent of the specific CAD system with which it was developed.

The formal report will include the English language rules and instructions for selection of materials and conformance with diagrams imbedded in the system, architecture description and flow charts and text describing system techniques and method of application to the project. At least two technology transfer demonstrations will be presented on sight at the Pascagoula, Mississippi shipyard.

PROJECTS FOR THE FUTURE

The following projects, as previously noted, have been approved by the SNAME Ship Production Committee and proposed to the Maritime Administration for funding in fiscal year 1985. Each project has been investigated to the point that potential sponsors have been identified as shown below. Each potential sponsor must submit a detail proposal satisfactory to the panel's Project Review Board and the panel general membership prior to subcontract award.

Project: Investigation of Design/Planning Organizations
Sponsor: Bath Iron Works

This project will examine alternative organizations used in design and planning departments and evaluate the advantages and disadvantages of each when applied to modern shipbuilding methods. Attention will also be directed to the short term transitional effects of adapting a recommended organization. The project report will include a recommended optimum organization for each product type observed during the study.

Project: study of the Application of Advanced Measuring Techniques to Shipbuilding
Sponsor: Newport News Shipbuilding

This project will identify advanced measurement techniques supporting the process requirements of modular construction, define the planning and procedures required for their use and specify, by shipbuilding process, the techniques found to satisfy measurement requirements in shipbuilding.

A joint study will be conducted by an appropriate university and the sponsoring shipyard. Measurement requirements will be-defined at representative stages of construction relative to the requirements of current and future construction techniques. Market place and industry surveys will provide potential methods of satisfying specific measurement needs at each stage of construction specified. Operational characteristics such as required planning and feedback time frame(s) will be defined. The preferred techniques for providing needed measurements will be identified.

The university will provide the research personnel and facilities to conduct necessary literature searches, industry surveys and scientific evaluations. The participating shipyard will provide the shipbuilding environment necessary for the university to develop planning requirements and operating procedures involved with the use of the new measuring techniques. The participating shipyard will conduct appropriate reviews of the university's work.

A report will be prepared by the university for use by shipyards in assessing their needs for, and use of, various advanced measuring techniques.

Project: Interface Impact - Systems to Zone Transition - Phase I I
Sponsor: Todd Pacific Shipyards, Los Angeles

This project will investigate the design products used for the basis ship in phase I of the project (FFG 7 Class Frigate) and using hindsight, suggest changes in the design and design products that would allow for more efficient block construction methods.

It is planned to use selective FFG erection blocks as a basis for the following:

- Reconstruct the conventional erection and outfitting sequence and identify work order tasks and allocated budgets to serve as baseline.
- Replan erection and outfitting sequences to reflect new on-unit and on-block construction methodologies in order to maximize the producibility of the selected modules.

- Analyze existing design to see if improvements in layout, configuration or standardization will further improve producibility.

- Compare findings against the Design For Production Manual to provide a basis for validation and comment.

- Recommend drawing format changes to support changes in erection methodology developed in the above effort.

A report of all findings including normalized statistics, graphics, photographs of areas studied and sample work instructions will be published upon project completion.

Project: Workshop on Management of Advanced Technology in Shipbuilding
Sponsor: To be determined via request for proposals.

Under the sponsorship of Panel SP-4, a university will assemble a panel of experts from academia, government and industry who will prepare and conduct a workshop for personnel of a lead shipyard. Recognized leaders in organization behavior, engineering and ship production will prepare and lead the workshop focusing on how to deal with the problems encountered in introducing technological change in a shipyard environment. Attendees will also explore the organizations and methods needed to identify and manage a viable and desirable technological change program, the identification and management of individual development projects and the resulting deployment and implementation of the new technology.

An Ad Hoc advisory group made up of members from Panel SP-4 and Panel SP-9, Education, will assist in the development and administration of the project. It is anticipated that the project final report will service as the basis for similar workshops at follow shipyards sponsored by Panel SP-9.

PLANNING

Panel SP-4 began a review of its long range plans at its meeting in New Orleans on February 6-7, 1985. Possible areas of need were identified and one stood out above all others: the necessity of a cooperative Navy-Industry effort to develop and apply computer technology to the ship design, construction and maintenance environment. The remainder of this report will cover our progress in addressing a mutually satisfactory and advantageous approach to Navy - Industry computerization.

The Navy asked the National Research Council in 1981 to identify promising technology developments having the potential to increase the productivity of U.S. shipyards. The ensuing multi-year effort was concluded with the publication of the NRC's final report

on the subject entitled "Toward More Productive Naval Shipbuilding" dated 1984. This report considered the advances in computerization to be of critical importance to shipbuilding productivity and specifically recommended development in the areas of:

- Common Engineering Data Base
- CAD/CAM Data Base Systems
- Interactive Data Transfer
- Management System Development

The report identified the industry - government cooperative effort known as the National Shipbuilding Research Program (NSRP) as an established and effective forum for research in the area of shipbuilding productivity. However, its examination of the NSRP program revealed a lack of significant effort in the specific areas noted above.

Panel SP-4 began its attempts to better define the needed development, and its role in the effort, with a March 4, 1985 visit by a representative group from the panel to Capt. John F. Leahy III, Program Manager for the NAVSEA Information Systems Improvement Program. This meeting was followed by a letter from SPC Chairman, Jesse Brasher to Capt. Leahy dated March 21, 1985 wherein Mr. Brasher noted that the Ship Production Committee should be one of the liaison points with the Navy in response to the National Research Council report's call for an industry - government task force on computerization. Mr. Brasher's letter also recommended that the SPC's contact point be Baxter Barham, chairman of Panel SP-4. Capt. Leahy's letter of April 29, 1985 responded to Mr. Brasher and accepted his recommendations.

Concurrently, and in an effort to provide the foundation for development of a proper program, the Ship Production Committee and the Maritime Administration (partners in the NSRP) arranged a mini symposium on the morning of April 30, 1985 to examine the existing and developing Navy plans for computerization. Panel SP-4 was invited to the symposium and was well represented by members from east, west and gulf coast yards as well as the Great Lakes area.

The SPC arranged for a special task force to meet the afternoon of that same day to formulate and recommend a plan of action. The SP-4 chairman served on the task force.

The task force led by Mr. R. W. Thorpe of J. J. McMullen Associates, Inc., included 15 members representing seven shipyards, three design agents, MarAd, NAVSEA and two consultants. The representation also covered the Ship Production Committee, Panel SP-4 and Panel SD-2, Computer Aided Design.

The task group's recommended plan of action was accepted the next day by the Ship Production Committee and included the following required action:

1. SPC form an Ad Hoc Executive Committee of key shipbuilding industry managers to review and approve industry computer based technology program plans and policies and to interface with Navy policy makers.

2. Panel SP-4, hold a workshop in June, 1985 to prepare a detailed plan.

Concurrently with, and independent of the above activity, the Navy considered the NRC recommendations and confirmed the need for work in the aforementioned areas of Navy - Industry computerization. This is documented in Assistance Secretary of the Navy Everett Pyatt's letter of April 25, 1985 to Mr. Lee Rice, President of the Shipbuilders Council of America.

With this background the SP-4 panel chairman conducted a workshop on June 11, 1985 to prepare a detailed plan as directed by the special task force report adopted by the SPC. An attempt was made to hold a workshop that included representation from a reasonable cross section of interested activities on the one hand while, on the other, limiting the size of the assembled group such that the complex subject could be adequately addressed. The result was a group of twenty people representing the following:

NAVSEA 507
David Taylor Naval Ship Research and Development Center
Shipbuilders Council of America
NAVSEA 506
Maritime Administration
5 - Shipyards
2 - Design Agents
1 - Consultant
Panel SP-4
Panel SD-2

Still, it was felt that the task of developing a detail action plan responding to the National Research Council recommendation for

- Common Engineering Data Base
- CAD/CAM Data Base
- Interactive Data Transfer
- Management Systems Development

would be difficult to accomplish in a group large enough to represent concerned and affected parties. Therefore, the following four individuals were asked to collaborate in developing a proposed plan to serve as a strawman at the workshop:

Rick Lovdahl - Todd Pacific Shipyards - LA
Jon Matthews - J. J. Henry Co., Inc.
Douglas Martin - NASSCO
James R. VanderSchaaf - Bath Iron Works

The workshop began by examining and defining the four areas of computerization focused on in the NCR report and as listed above. It was agreed that Data Transfer is:

- An immediate problem
- Best defined of the listed areas
- Involved common Engineering Data Base and CAD/CAM Data Base Systems
- Capable of being addressed practically
- The proper place to begin an ongoing action plan.

The "Strawman" presented by Jim VanderSchaaf was based on the DDG 51 lead yard - follow yard relationship and principally addressed data transfer. After considerable discussion it was agreed that the "Strawman" contained essential elements that should be included in a formal proposal made to the Navy. However, it was also agreed that the proposal should accommodate the following added ingredients:

- Definition of need.

  In addition to the Navy's need to provide for the life cycle maintenance and distribution of thousands of drawings per ship, there is a pressing need for a coordinated effort to develop generic industry - wide/ Navy wide solutions. Valid but different solutions to the same problem will result if the needs are separately addressed by two or more parties.

- Data transfer from the Navy (owner) to the lead yard

- Transfer of data from lead and/or follow yards to the Navy

- DDG 51 and SSN 21 programs should be coordinated.

The programs should benefit from each other and avoid, if possible, two solutions to a single problem.

- DDG 51 and SSN 21 solutions must be developed in a manner and time frame that will support those ships' programs and schedules.

- Resolution of DDG 51 data transfer problems should involve all potential follow yards.

- SP-4 provides the mechanism for industry wide involvement.

  'Practically speaking, the panel's involvement on the DDG 51 and SSN 21 programs could be advisory in nature.

- ST-4 in conjunction with the Navy should develop generic standards building on the DDG 51 and SSN 21 experience.

- The program thus established could be the beginning of a continuing effort to define and address evolving Navy- industry problems/opportunities related to computerization.
- A defined deliverable
- Estimated Cost
- Proposed Schedule

John J. Nachtsheim and J. R. VanderSchaaf agreed to develop an unsolicited proposal based on the technical strawman prepared by Mr. VanderSchaaf and modified to incorporate the above features. The schedule for completion is August 26, 1985 which follows the preparation of this report.

'Panel SP-4 met on June 12, 1985 and endorsed the plans developed at the workshop the preceding day. It is planned to present the unsolicited proposal now under preparation to the Ship Production Committee for action during their meeting to be held during the Ship Production Symposium, September 10-13, 1985.

Panel SP-4 will meet again October 15-16, 1985 to plan next year's activity. It is important that the question of Navy - industry computerization be addressed. We believe a viable program will result from the program outlined above in that it does the following:

- Addresses the need established in the National Research Council report.
- Agrees with the objectives and direction included in Assistant Secretary of the Navy's letter of April 25, 1985.
- Utilizes an existing industry technical organization thereby avoiding added administrative costs.
- Has timely applicability to two important and current Navy programs.
- Benefits from the schedule demands of the associated Navy programs.
- Establishes a mechanism for continuing resolution of problems associated with the application of computer technology to shipbuilding and life cycle maintenance.

CONCLUSION

This panel overview has described a very active program based on the premise that design is the first step in the production sequence. The need is not just better communication between the design and production functions, but rather the integration of those functions. This integration requires a full understanding of the ship design and building processes, an agreed strategy for building each ship, proper tools and the approprate application of computer technology. It also requires the shipbuilder to be alert and innovative and amenable to constructive change.

Panel SP-4 logically addresses the problems of design production integration through a program of related projects and a sound planning program. Consider the following:

- The projects'to develop a Design for Production Manual, investigate Interface Impacts in System to Zone Transition and provide a Workshop on Management of Advanced Technology in Shipbuilding are all intended to promote understanding of the tasks at hand.

- Work to develop a Product Work Clarification and Coding System and a Computer Aided Process Planning System are mutually supportive efforts to provide needed tools.

- Discovery of new tools and the better application of existing tools should result from the study on the Application of Advanced Measuring Techniques in Shipbuilding.

- Efforts to recognize and accommodate responsible change are reflected in the projects to investigate the Information Flow Requirements of Design and Procurement Functions, explore the Required Content and Format of Engineering Documentation and research Design/Planning Organizations.

- The appropriate application of computer technology is manifest in many of the program projects. The Product Work Classification and Coding System is required to be computer compatible, its use in the Computer Aided Process Planning System is obvious and the effort to Develop Specification Driven Piping Arrangement and Detail Drawings depends on the computer to discipline the selection of materials and configurations. The recently published "Software Tools for Shipbuilding Productivity" shows the way to cost effective integration of isolated computer applications and opens the door to growth in computer applications through a responsibly planned program.

- Appropriate planning, as demonstrated by the panels involvement in the SPC approach to Navy - industry computerization, has included recognition of need, the location of required expertise and a reasonable approach to industry wide results.

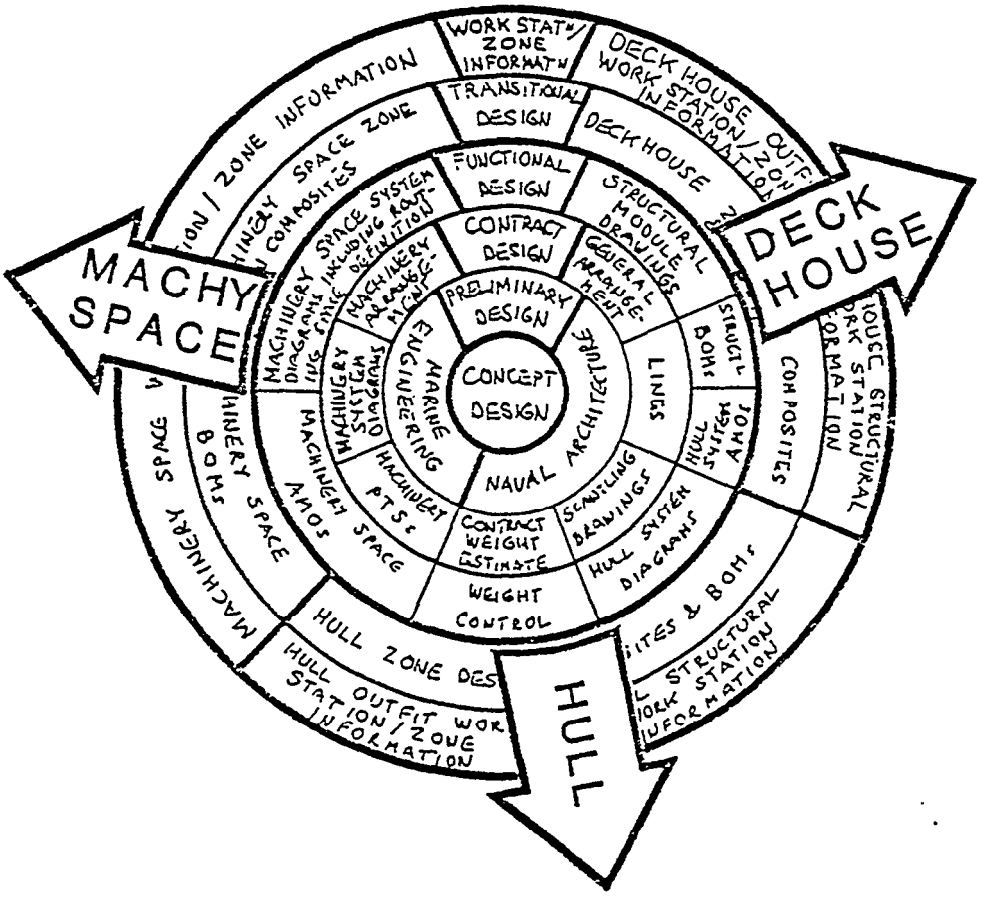
Panel SP-4, Design Production Integration, is still working to assist U.S. Shipbuilding attain and maintain a competitive position in Time-Cost-Quality. Comments and questions will be welcomed by the panel and may be directed to:

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ENGINEERING MANAGEMENT

FOR

ZONE CONSTRUCTION OF SHIPS



BY

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ENGINEERING MANAGEMENT FOR ZONE CONSTRUCTION OF SHIPS

by

Thomas Lamb B.Sc., P.E.

ABSTRACT

Zone construction has been proposed as the way for the U.S. shipbuilding industry to improve its productivity and survive the current hard times. Obviously as the production requirements for zone construction are different to traditional ship construction so are the engineering. While production could perform zone construction from traditionally prepared engineering it would do so inefficiently and after waiting a long time for most of the engineering to be completed before they could start, thus defeating one of the goals of zone construction.

The production department in a shipyard changing to zone construction will probably reorganize into major zone sections. To obtain maximum benefits from zone construction it is necessary for the engineering department to be like organized and managed. The paper therefore discusses engineering aspects that are influenced by the change to zone construction.

CONTENTS

1.0 Introduction

2.0 What is Zone Construction?

3.0 Engineering Requirements for Zone Construction

4.0 Engineering Organization for Zone Construction

5.0 Engineering Staffing for Zone Construction

6.0 Engineering Training for Zone Construction

7.0 Engineering Planning for Zone Construction

8.0 References

9.0 Acknowledgements

1.0 INTRODUCTION

Management has been defined as the universal process of accomplishing work through others. It consists of handling and making decisions on many conflicating requirements at the same time. Because of this, management analysts try to eliminate the complexity by conveniently dividing it up into functions and then discuss each function and the relationships between them. The four functions that are always listed are:

- 0 Planning
- 0 Organizing -
- o Directing
- 0 Controlling

Other functions that are sometimes listed are:

- o Leadership (a directing function)
- o Assembling Resources (part of organizing)
- o Staffing (part of organizing)
- o Training (part of organizing)
- o Communication (part of directing)
- o Decision Making (involved in all functions)
- o Budgeting (a planning function)

The additional functions can all be considered subsets of the first four as shown by the relationships indicated in parentheses.

Planning is the WHO, WHAT, WHERE and WHEN decision phase of management. It utilizes tools such as Work Breakdown Structures, Task Listings, Sequencing, Networking and Critical Path Method along with engineering and manufacturing skills to select an efficient approach to designing, procuring material, and constructing a product.

Organizing consists of the design of the organization, its staffing and training.

Directing is the ordering by commands, instructing by example or suggesting by consultation, of the necessary actions to obtain the desired results. It is here that the "art of management" is truly most applied. This art, as well as controlling people, is the melding of the planning and organizing which in turn are tools or systems to determine if the "art" was successful in accomplishing the plan.

Controlling is the analysis of operating results in comparison with the plan If the results do not conform,. action must be taken to improve the future results so that the final outcome will achieve or better the plan. Controlling also involves feedback of the results so they can be used by planning in the future. The control of any business endeavor requires the following basic knowledge:

- What has to be done?
- When should it be done?
- What resources does it require?

With this knowledge, managers can control the work if the following feedback is provided:

- Is the work being done on schedule?
- Is the performance better or worse than budgeted?
- How can problems be corrected?

Any management control system must address all the above questions.

There is an obvious logical sequence of these functions for every project, namely, planning, organizing, directing and controlling. Once initiated, the control function may require continuous re-planning and re-directing if results are not to plan.

Some of these management aspects will be discussed in regard to Engineering for Zone Construction, but before this is done, it is worthwhile to set the scene to which they would be applied.

There have been and, notwithstanding the current world shipbuilding recession, still are many successful shipbuilding companies in the world. The engineering organization of these successful companies, although similar,

probably has significant differences. These differences are due to the development of the companies, their products, and the skills and experience of their employees and their managers. The development of today's shipbuilding engineering organizations evolved as engineering work was split into hull and machinery, and then into structure, outfit, hull systems and machinery, machinery and electrical. Through time, design and technical calculations were separated from working drawing preparation. In most engineering organizations, these divisions or as they are often called, disciplines, still exist. However, the way ships are designed and built has significantly changed over the last 25 years. It is surprising to many that engineering organization did not change during this time to suit the design and building methods.

In addition, during the same time frame, another significant change that directly affected engineering requirements occurred, namely; the demise of the craft apprenticeship system. This resulted in the workers being less 'skilled and experienced, and required more and easier to understand data and instructions from the engineering organizations. The craft organized shipyards worked from the minimum of engineering and-the well trained and experienced workers developed their own details. Because of this, engineering and production often were isolated from each other. Today's Zone Construction shipbuilding

necessitates a very close relationship between planning, engineering, and production employees. It also requires an intimate knowledge by the engineers of the methods used, and the difficulties involved in constructing a ship in the facility for which they work. Details can no longer be left to be solved by the loft, shipfitter, or pipe shop! Even though this approach appears to place more responsibility on the engineer, in general, it is more logical and interesting. Therefore, it is usually enthusiastically accepted by the engineer. Unfortunately, it has been met with mixed emotions by other departments in shipyards.

The reasons for this are many, ranging from incursion into "their area", to insulting their intelligence by the issue of simpler but better instructions. Neither reason, or any in between, are justifiable. Everyone in the shipyard should be working as a team, ready to adapt to whatever approach helps it to achieve the goal of competitive ships in minimum construction time. An efficient, successfully operated company should be like a set of precision gears, each department like many input shafts with gears meshing with the production department, which of course is the output shaft. 'This concept is shown in Figure 1. Incidentally, communication is the necessary lubricant for the organization (gear) and the collection of the lubricating oil and its processing for return to the

gear is the organization's feedback. For optimum performance, all service departments (input gears) must mesh with the production department (output gear) in exact accordance with the organization (gear) design. It must operate like a properly lubricated and maintained set of precision gears. If any service department tries to do more or less than it is required to, or if the production department tries to drive a service department, then the total organization output diminishes, and the output gear will become overloaded and may self destruct. Only by each part of the organization functioning as they are designed to, will the efficiency approach its optimum. A set of precision gears will achieve 98% efficiency. It is doubtful if any organization can claim any where near this value. Just as it is essential for the desing of a gear the detail requirements for each part of the organization must be fully understood to complete the design successfully. Therefore, it is essential that the objectives and results for each department be clearly defined, and the responsibility, authority and accountability be correspondingly assigned to the departments.

Like most things in life, there is more than one way to approach the design of an organization, but in all cases, the engineering goals must be clear and the resulting organization must be capable of achieving the goals.

Even then it is only possible if all involved use the organization in the way it is designed. If employees or worse, management, do not enthusiastically adopt the new organization, full benefit from the reorganization will not be achieved.

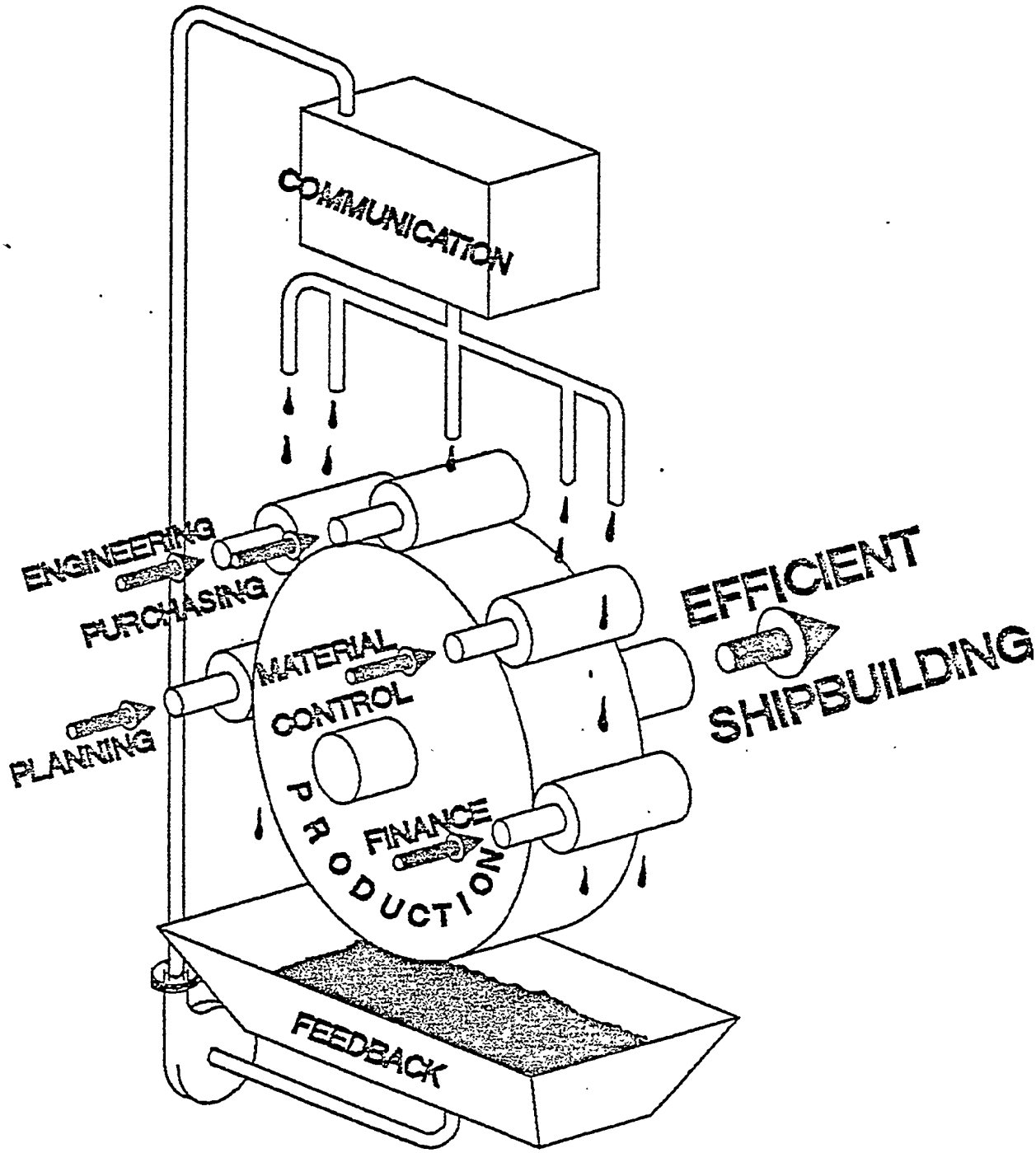


FIGURE 1 - THE COMPANY GEAR

2.0 WHAT IS ZONE CONSTRUCTION?

Zone Construction is the name given to the shipbuilding technique wherein the construction of the structure, distributive systems, outfit and equipment, and installation of same are integrated and occur when the ship is in modular or partially erected stage. The normal breakdown into system disciplines, such as structure (shell, deck, bulkhead, etc.), piping, HVAC, electrical, paint, etc., tend to disappear and all items become interim products. To accomplish this, the ship is divided into zones, thus the basis for the name. The division can be a hierarchical system or simply sequential, or any combination in between these extremes. Figure 2 is an example of the first type and Figure **3** the latter. A beneficial way to handle zone construction is to consider each ship zone as a work station and then the concept of zones can be integrated with the shipyard facility work stations.

Shipyards utilizing the Zone Construction approach are identifiable by constructing ship structure in modules (Figure 4) and incorporating extensive advanced outfitting (Figure 5) They will also be organized by major zone (or product) such as Hull, Deckhouse, and Machinery Spaces. Fully outfitted deckhouses will be the form rather than the exception (Figure **6).** In addition, a major aspect is the compression of the design/build cycles shown in Figure **7.**

The benefits of Zone Construction are many and are covered in the many MarAd/SNAME SP-2 publications (1, 2 & 3) and the MarAd/Avondale Technology Transfer Symposia (4). The major ones are as fellows:

- Improved productivity
- improved quality
- Improved worker safety
- Logical sequencing of work
- Earlier start to outfit fabrication and installation, thus better utilization of outfit trades throughout the duration of construction rather than heavy concentration near the end.
- Clearer responsibility for complete design and construction of each zone.

These all result from an integrated design and installation of outfit at or near ground level, in better facilities and at best attitude.

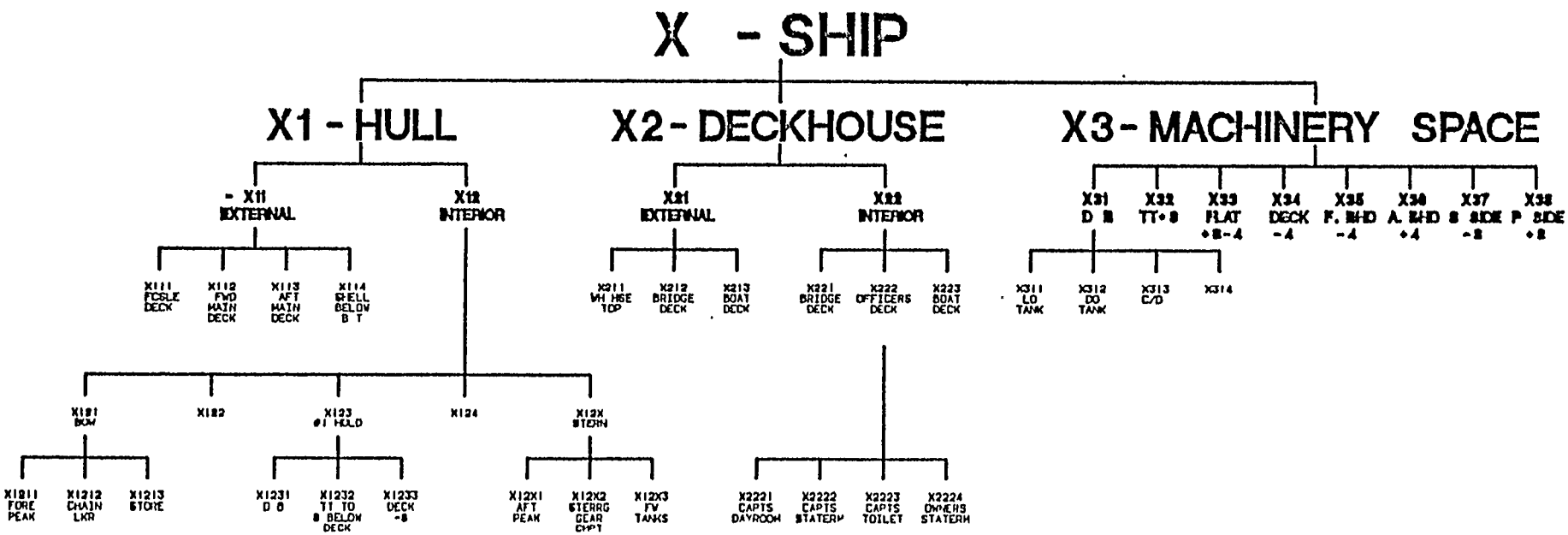


FIGURE 2 - HIERARCHICAL ZONE DESIGNATION SYSTEM

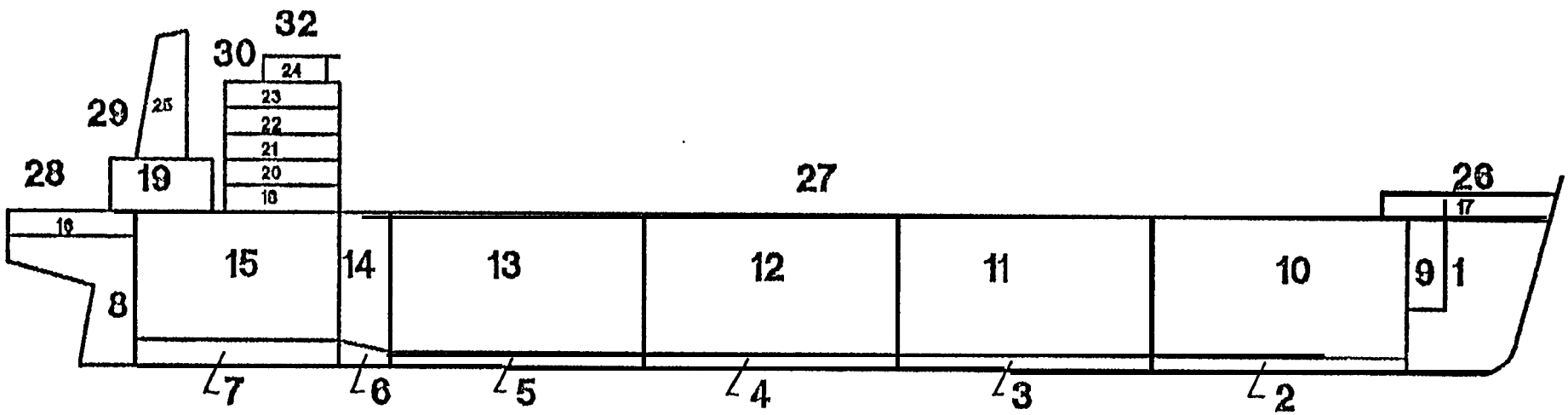
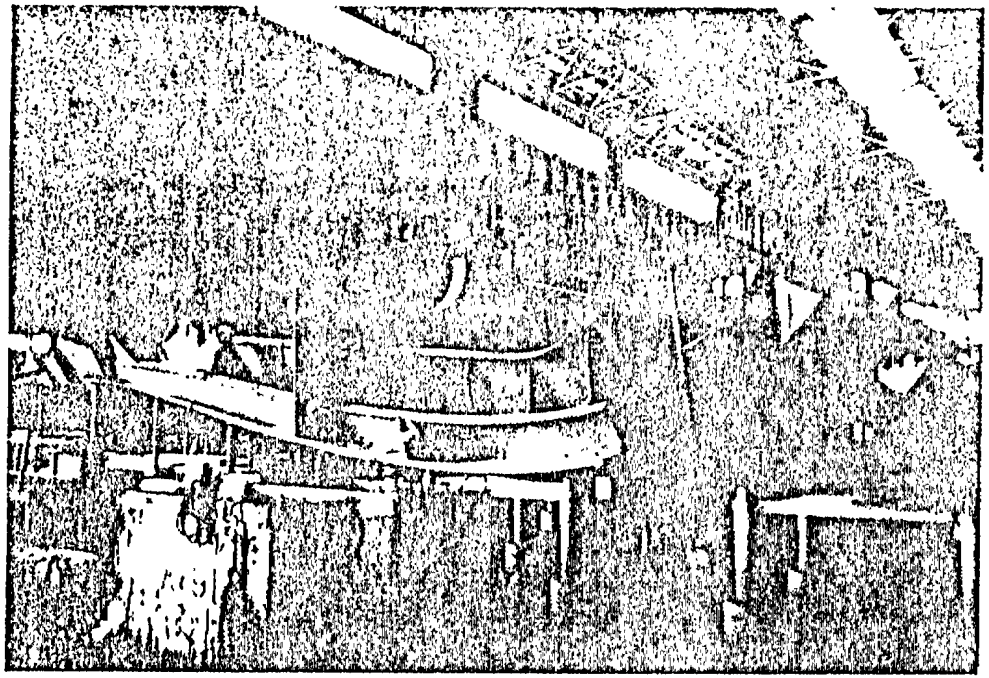
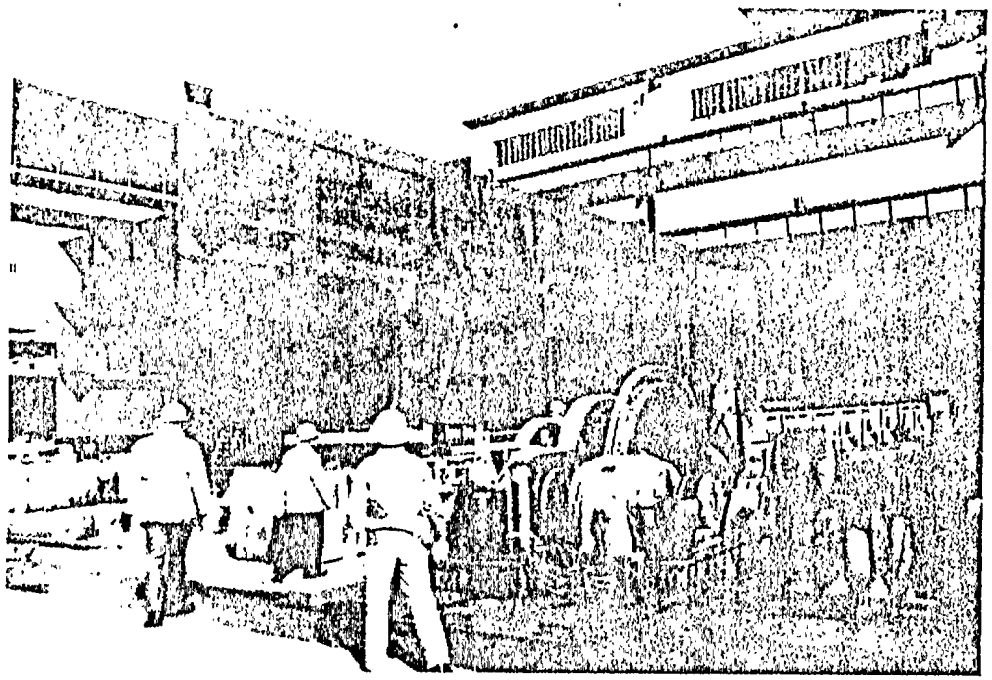


FIGURE 3 - SIMPLE SEQUENTIAL ZONE DESIGNATION SYSTEM





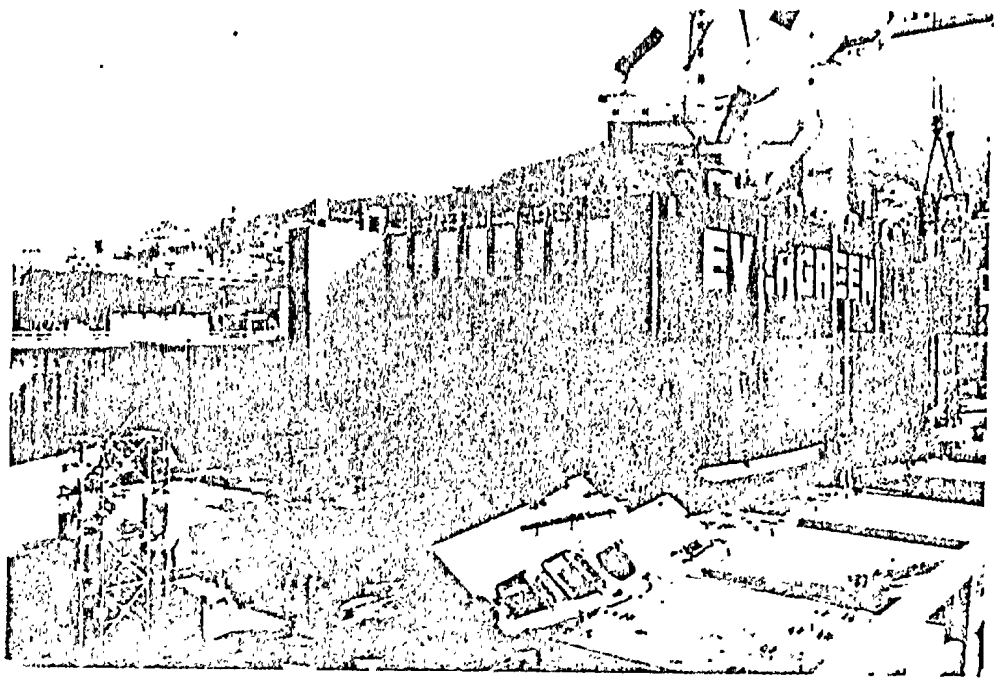
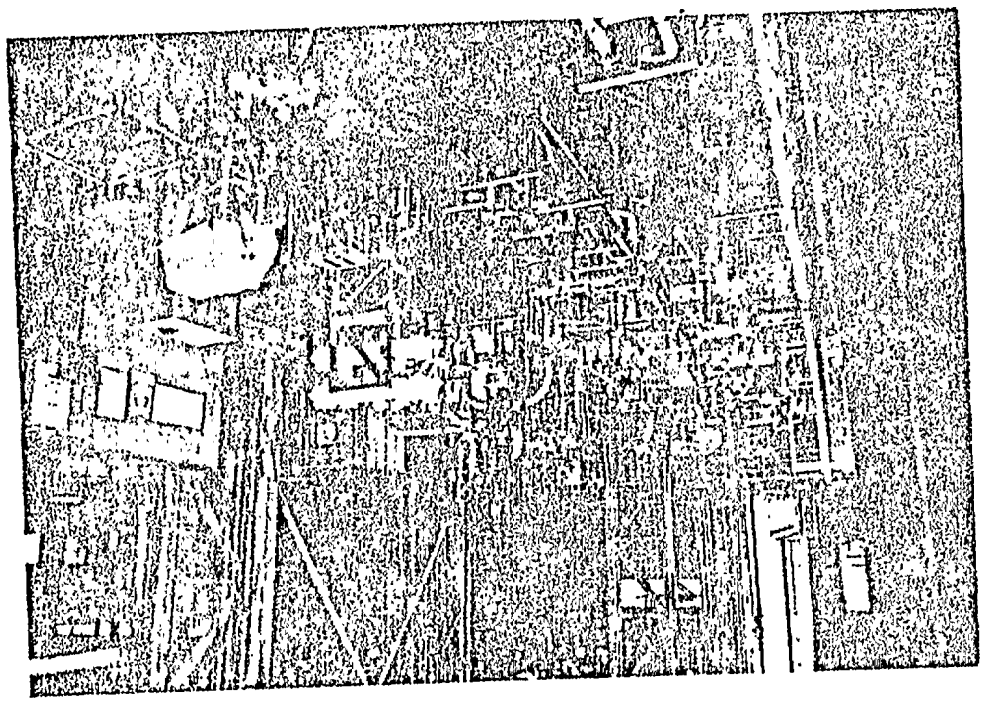
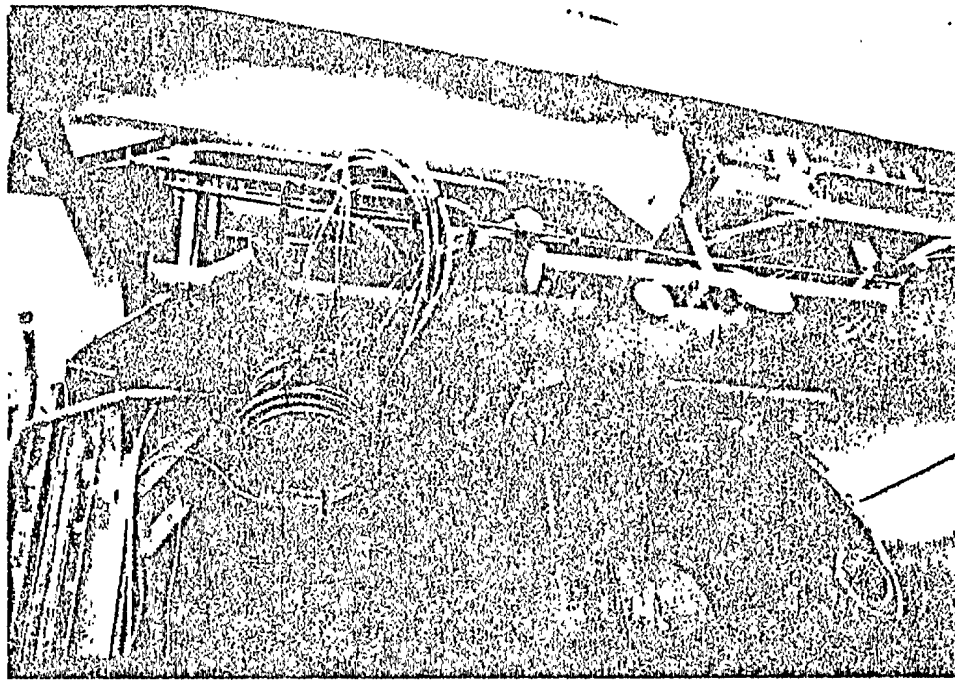


FIGURE 4 - STRUCTURAL MODULAR
CONSTRUCTION OF SHIPS





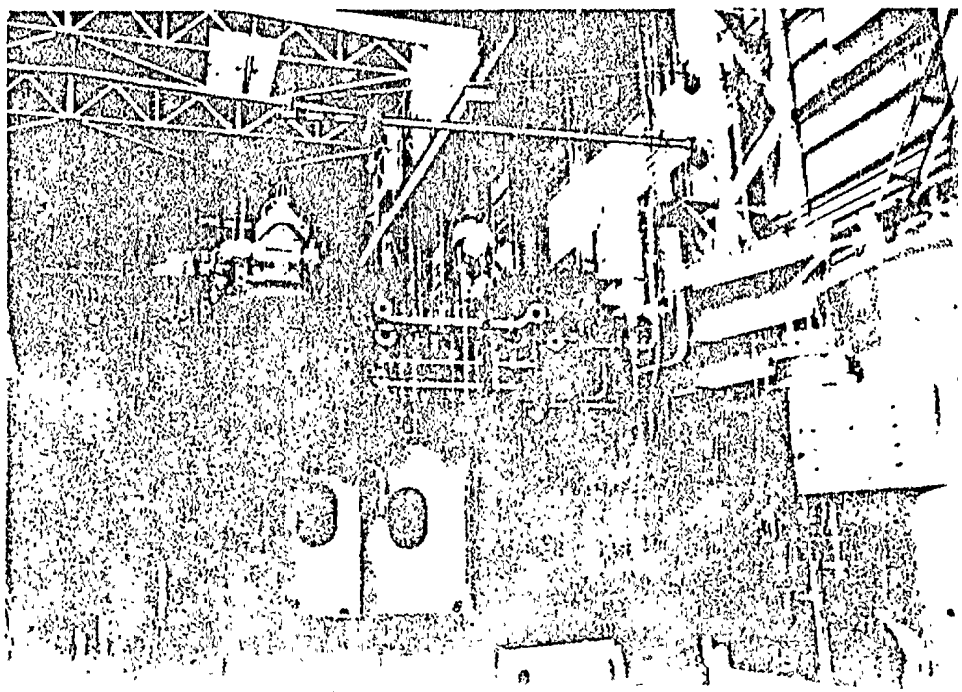


FIGURE 5 - ADVANCED
OUTFITTING

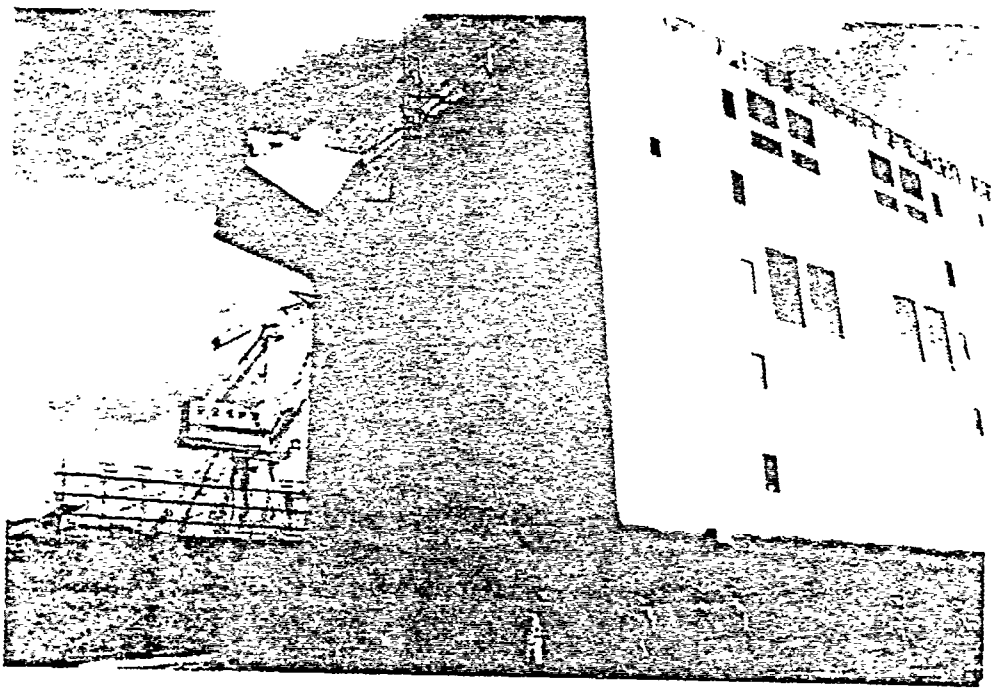


FIGURE 6

DECKHOUSE COMPLETED BEFORE ERECTION

3.0 ENGINEERING REQUIREMENTS FOR ZONE CONSTRUCTION

Zone Construction requires engineering information to be prepared in a different way and in a different sequence and schedule to the traditional approach. In order to understand the differences, it is necessary to review the traditional approach before defining the zone construction requirements.

Not, withstanding the fact that all engineering design should be prepared to be the best possible for production and thus the most cost effective, it seems that ship designers have not kept this in mind as the industry changed from craft to a process activity. Over thirty years ago, shipyards were craft organized and the various engineering groups as well as production groups tended to work in isolation from each other. The amount of detail shown on the engineering drawings was quite small as the craftsmen were expected to and were able to use their training and experience to develop details on the job. As long as ships were assembled on the building berth in many small individual parts, this system worked quite well. Productivity depended almost entirely on the effort and ability of the production craftsmen. When welding replaced riveting, two important changes took place. First, it required better accuracy in cutting and fitting parts, which provided the impetus to develop better lofting and steel processing through optical projection and then

computer aided lofting and computer aided manufacture. Second, it enabled structural pre-fabrication to take place in shops and platens away from the building berth.

Another significant event in ship production occurred during World War II when the U. S. was called upon to be the shipbuilder to the Allies. The techniques adopted at the multiple ship shipyards were geared toward mass production, and to overcome the use of inexperienced labor. Extensive prefabrication was planned into the design to allow an assembly line approach to be used. Simplified. engineering drawings were provided to the workers. Very detailed planning and scheduling of material receipt, processing and installation were used along with a highly developed production control of the construction processes. This was possible due to the repetitive processes performed at each work station. Erection panels of up to 50 tons were handled in some of the shipyards. At the end of the war, many shipbuilders closely examined the techniques developed in the U. S. shipyards and adapted them to their own facility, and in some cases improved on them, as in the case of the National Bulk Carriers shipyard in Japan and the impressive shipbuilding achievements in Japan and Europe in the 1960's.

Out of this era of noticeable change followed by the depressed shipbuilding market of the late 70's, the need for consolidation of facilities and ship production

techniques developed. Along with this came the clear need for ship designers to become cost conscious as they applied their talents to the design of future ships.

This must be accomplished by using the most efficient method of construction while still satisfying the many compromises resulting from conflicting requirements between the owner's desires, regulatory and classification rules, and the need to have a competitive edge over the other shipyards. However, many shipyard engineering departments continue to work in isolation, without taking into account the producibility of their designs.

Fortunately, it is possible to obtain significant increases in productivity in existing shipyards without large investments in plant and construction equipment by redefining the ship construction approach, and planning the construction of the ship at the same time as the preparation of the drawings, thus being able to influence the design to suit the intended building plan. This also required the engineering to be prepared to suit the construction approach.

Table I summarizes the major differences between Traditional and Zone Engineering along with the benefits of the latter. Figure 8 shows a typical design, engineering and production schedule for the Traditional approach and Figure 9 shows the same for Zone Engineering approach. By comparing the two approaches, it can be seen that the latter approach

enables the production department to commence construction earlier and to complete the ship in a shorter time than the Traditional approach. This is because the engineering information for the first Zone (module) is completed earlier than would be the many item drawings that the traditional engineering approach requires before construction could commence. This, in turn, enables the lofting, processing, assembly and outfitting of the module to occur earlier resulting in the shortening of the construction time.

The optimum engineering information transmittal format for Zone Construction is a drawing or sketch and part list for each workstation (including zones on board the ship). This is not only for structure but for all other systems. A work station drawing (sketch) shows all the work that occurs at one location, such as platten, shop, machine, module or zone. It can be one sheet showing the completed product at the end of all the work to be completed at a given work station with written sequence (process) instructions or it can be a series of sequential construction sketches showing the build up of the product from the received parts to its completed status for the work station.

Zone Construction requires engineering for all systems to be available at almost the same time as that for the structure. It also requires an integration of material

procurement with the development of the engineering for each zone so that the required material will be available as early as possible. This change in time of preparation of engineering data can be seen from Figure 10.

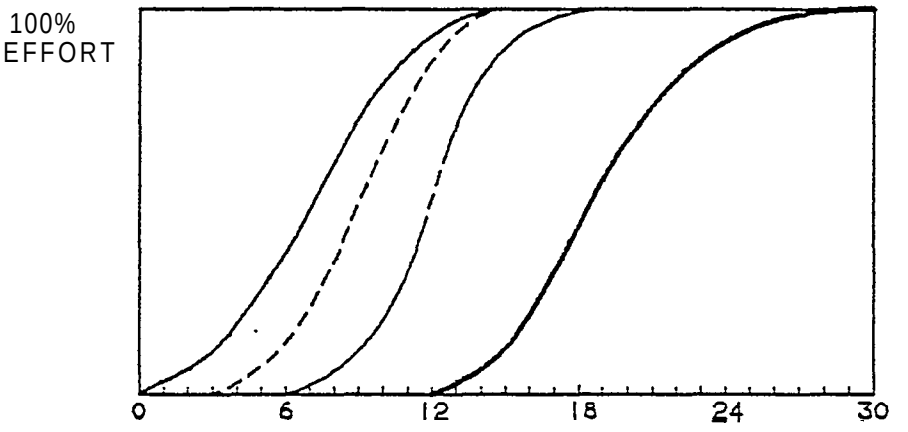
TABLE 1 - COMPARISON OF TRADITIONAL AND ZONE ENGINEERING

ENGINEERING

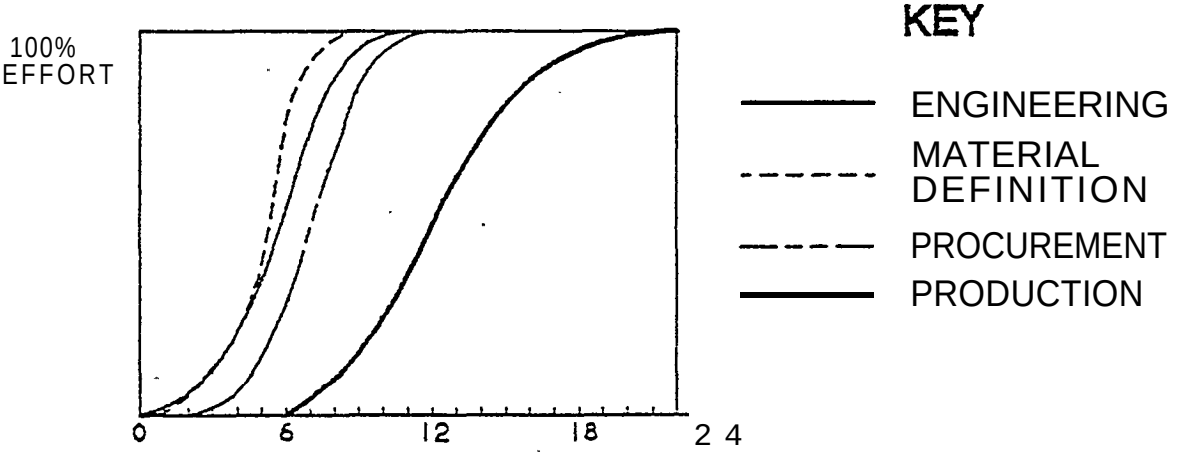
TRADITIONAL	ZONE	BENEFIT
Structural drawings prepared on item basis from bow to stern, e.g., - Shell drawing - Deck drawing - Bulkhead drawing - Tank top drawing - Framing drawing	Structural drawings prepared on a construction sequence basis for subassemblies, assemblies and blocks, e.g., - Web frame subassembly - Transverse bulkhead assembly - Double bottom block - Wing tank block	1. With traditional approach, construction cannot be started until a number of item drawings are complete. For example, one block required 13 drawings to show necessary data. With zone approach, construction can commence when the first block drawing is complete. 2. With traditional approach, it is necessary for someone (Production Planning) to prepare block parts lists and sequence assembly sketches. With zone approach, production can use engineering-prepared drawings directly, thus saving additional effort and time.
Machinery arrangements laid out for individual equipment and piping installation.	Machinery arrangements laid out for "OnUnit" advanced outfitting packages and piping and grating package assemblies.	"On Unit" advanced outfitting has been demonstrated to be the greatest productivity improver. Also allows work to be performed on unit and the ship to be completed earlier.

TRADITIONAL	ZONE	BENEFIT
System diagrammatics prepared for design use only in preparation of A&D drawings with no particular accuracy in equipment location or pipe routing.	System diagrammatics prepared accurately as possible including scheming for pipe routing with other system5 and showing all information required for material procurement and planning.	1. By integrating all system diagrammatics in a given space, the grouping for piping of various systems can be considered. 2. Also, knowing that the diagrammatics are more accurate allows material to be ordered with greater confidence which reduces the need for margins. 3. More complete diagrammatics are acceptable for complete owner and classification approval, i.e., it is not necessary to send A&D drawings for approval.
A&D system drawings prepared for complete ship or areas of ship without regard to block breakdown or "On Unit" advance outfitting. Usually prepared as independent drawings for each system, thus making integration and grouping of piping and supports together for installation difficult, if not impossible.	System working drawings consist of final instructions to the production worker, such as spool sheets, installation sketches and material lists suitable for direct incorporation in work packages.	1. Elimination of traditional A&D system drawings. 2. Earlier availability of construction information for piping. 3. Prepared on a zone basis, earlier installation of piping. 4. Eliminates current additional step which can introduce human error which can mushroom due to unexpected interferences and/or rework.

TRADITIONAL	ZONE	BENEFIT
Engineering drawings, data, etc., that are unsuitable for direct issue to Production, must be further processed by Production Planning.	Engineering prepares all production-required drawings and data, such as structural sub-assembly, assembly and block sequencing sketches, pipe spool sketches, advanced outfitting drawings and lists,	1. Increase in mutual engineering/ production knowledge and cooperation. 2. More problems solved on paper rather than on hardware.
No input for advanced outfitting.	Prepares advanced outfitting drawings and parts lists.	1. Engineering designs ship to facilitate advanced outfitting. 2. Forces material definition to support advanced outfitting. 3. Results in a more integrated ship.
Lofting is prepared from and therefore after detailed structural drawing is completed.	Lofting is an integrated part of structural development. Usual detailed drawings eliminated.	1. Shortened time from contract award to cutting steel. 2. Increased productivity of combined engineering and lofting.
Independent planning and scheduling keyed to a master event schedule.	Integrated planning and scheduling for Engineering, Materiel procurement, and Production for individual work packages.	1. Compatibility of all detailed schedules. 2. Effect of change on one department automatically apparent to other departments. 3. Schedule items identifiable to simplest production package.



TYPICAL TRADITIONAL
PERFORMANCE SCHEDULE



REQUIRED SHORT BUILD CYCLE/
PERF0RMANCE SCHEDULE

FIGURE 7 - COMPARISON OF TRADITIONAL AND COMPETPTIVE CONSTRUCTION SCHEDULES

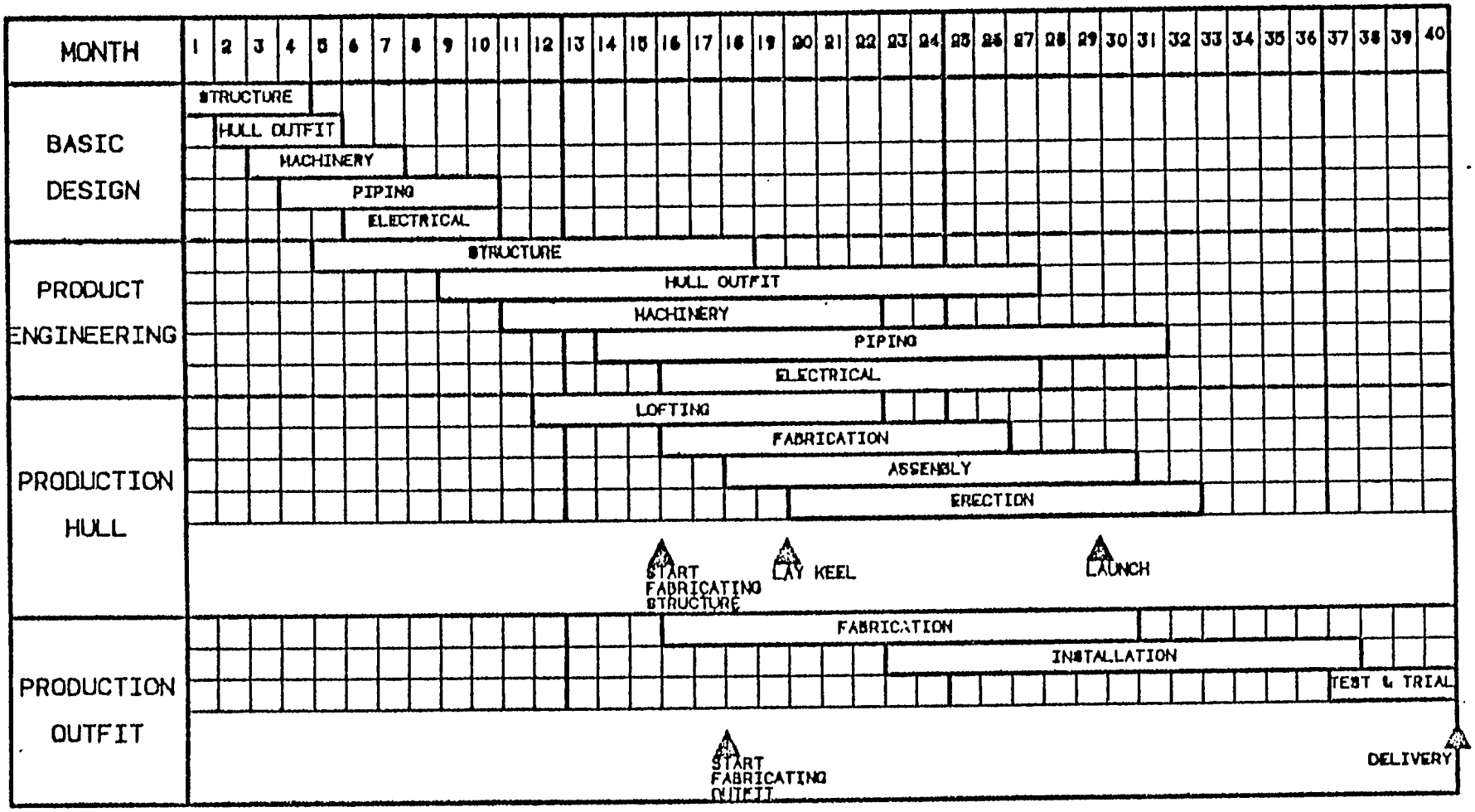


FIGURE 8 - TRADITIONAL SHIPBUILDING AND ISOLATED ENGINEERING

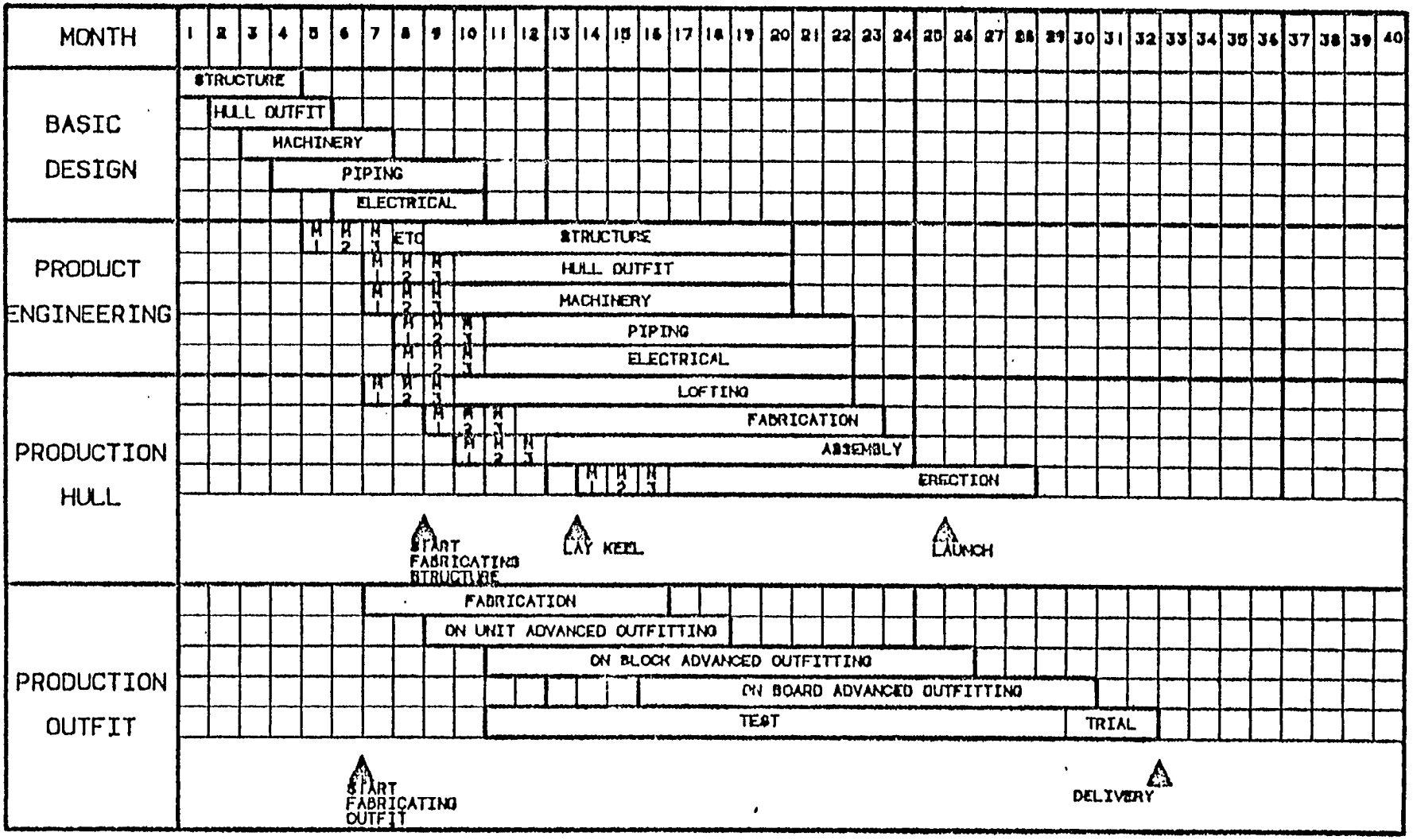


FIGURE 9 -ADVANCED SHIPBUILDING AND INTEGRATED ENGINEERING

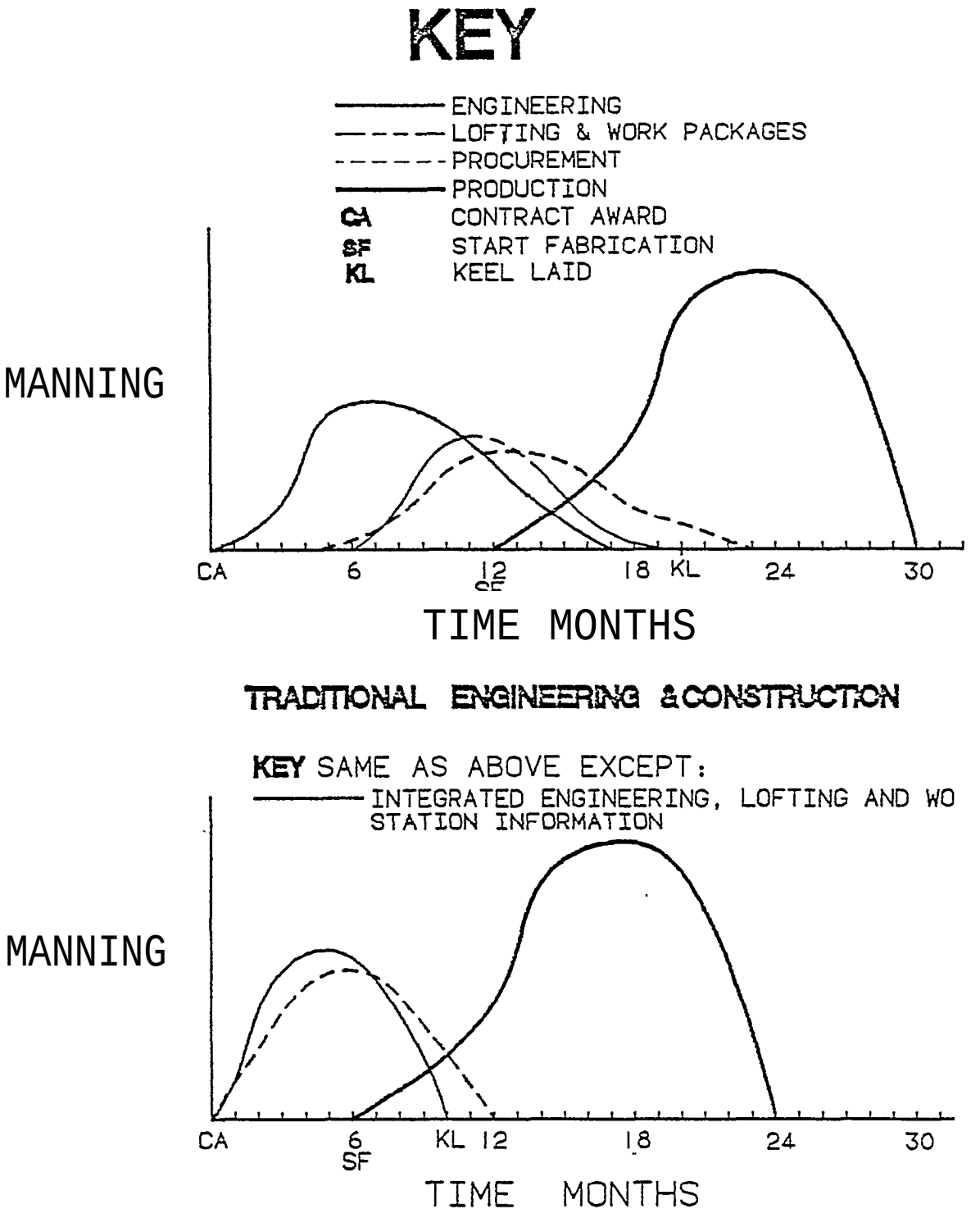


FIGURE 10 - COMPARISON OF MANNING SCHEDULES
FOR TRADITIONAL AND ZONE CONSTRUCTION

The design engineering process can be conveniently divided into BASIC DESIGN and PRODUCT ENGINEERING as shown in Figure 11.

Basic Design covers all design from conceptual through to system, quantity and material design. This process has again been conveniently divided into Concept, Preliminary, Contract and Functional Design. All but the last must be performed before\-, the award of a construction contract. Functional Design is the phase where the Contract Design is expanded to contain all design decisions. Table 2 lists typical Functional Design tasks.

Product Engineering covers all tasks required to transmit construction information to Production, and other shipyard departments. It again is divided into two phases. The first, Transitional Design, is the task of integrating all design information into complete zone detailed arrangements. The second, Work Station/Zone Information Preparation, is the task of providing all drawings, sketches, part lists, process instructions, production aids (such as N/C tape) required by Production and other service departments to construct the ship. Table 3 lists typical Work Station/Zone Information Preparation tasks.

Obviously, this approach to engineering will require additional manhours to accomplish it. However, as shown in Figure 12 the overall result of Zone Construction is a reduction in <u>total</u> manhours to design, engineer, plan and construct a ship.

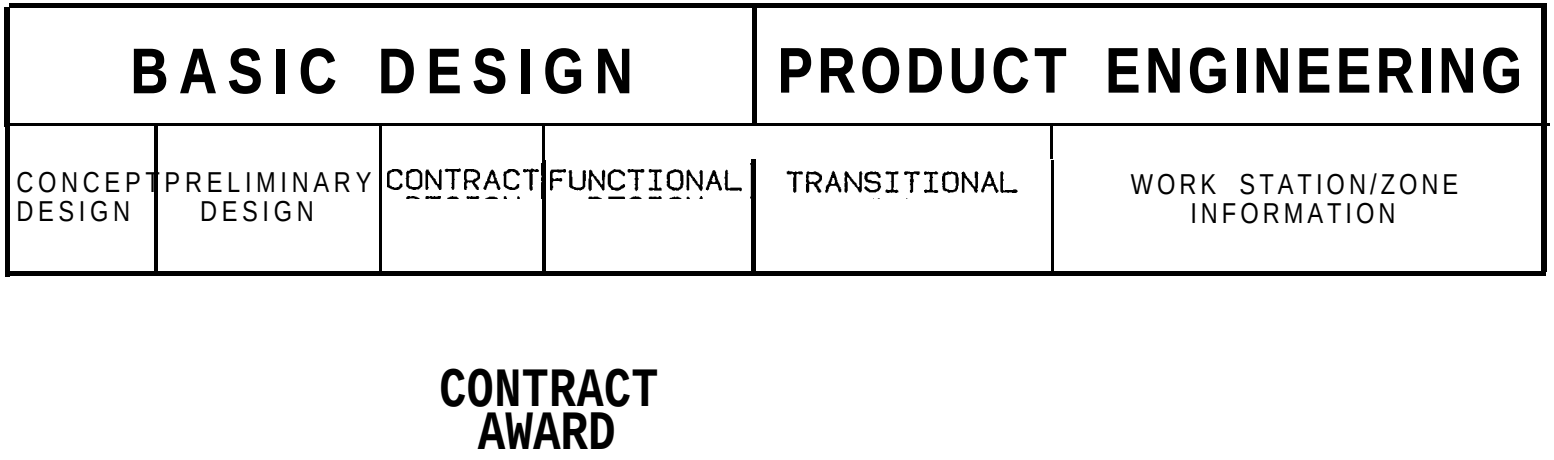


FIGURE 11 - PHASES Of ENGINEERING FOR ZONE CONSTRUCTION

TABLE 2

FUNCTIONAL DESIGN

HULL

General Arrangement

Outboard Profile

Lines

N. A. Drawings

Structural Module Drawings

Major Foundations

Weights, Centers and Lifting Data

Lists of Hull Outfit

Lists of Hull Fittings

Nameplates and Notices

Summary Painting Schedule

Summary Deck Covering Sequence

Summary Hull Insulation Schedule

Furniture List

Plumbing and Fixture List

Galley Arrangement

Accommodation Arrangement

Steering Gear Arrangement

Rudder and Rudder Stock Arrangement

Rudder and Propeller Lifting Gear Arrangement

Anchor Handling Arrangement

Mooring Arrangement

Life Saving Equipment Arrangement

Hull Piping System Diagrams

Purchase Technical Specifications

TABLE 2

FUNCTIONAL DESIGN

HULL - Continued

Advanced Material Ordering Lists

Steel List per Module

MACHINERY AND PIPING

Machinery Arrangement

Shafting Arrangement

Stern Tube Arrangement

M/C Space & Wheelhouse Control Console Arrgt.

Machinery Piping System Diagrams

Diesel Exhaust Arrangement

Lifting Gear in M/C Space

M/C and Pipe Insulation Schedule

ELECTRICAL

Electrical Load Analysis

One Line Diagram

Short Circuit Analysis

List of Motors and Controllers

List of Feeders and Mains

Electrical E &I Diagrams

List of Portable Electrical Equipment

HVAC

Heating and Cooling Analysis

HVAC Diagram and Equipment List

TABLE 2

FUNCTIONAL DESIGN

HVAC - Continued

HVAC Insulation Schedule

TABLE 3

WORK STATION/ZONE INFORMATION

A. For Structure - Work station information consisting of:
   - Sequenced isometric construction sketches and part lists for subassemblies.
   - Sequenced isometric construction sketches and part lists for assemblies.
   - Sequenced isometric construction sketches and part lists for modules.
   - Sequenced isometric construction sketches and part lists for module erection.

B. For Piping - Pipe assembly sketches and part lists. Sequenced pipe installation sketches and part lists for A/O units and zones.

C. For HVAC - Duct assembly sketches and part lists. Sequenced installation sketches and part lists for equipment and ducting.

D. For Machinery - Sequenced installation of equipment (in conjunction with piping, electrical, HVAC) for A/O "On Unit", "On Block", "On Board", and Zones.

E. For Electrical - Cableway installation for each module/zone including part lists. Cable lengths and numbers per section for each module/zone. Equipment installation sketches and part lists for each module/zone.

F. Hull Outfit - Sequence installation sketches and part lists for mooring fittings, doors, windows, ladders, handrails, paint, insulation, joiner work, deck coverings, deck machinery, furniture, galley equipment, provision store rooms, etc., for zones.

TABLE 3 - Continued

G. For Advanced Outfitting - Sequenced construction and installation sketches and part lists for foundations, grating, floor plates, equipment, pipe, electrical, and hull outfitting joiner work and furniture for units, modules-and zones.

All the above work station/zone information will be designated for either Hull, Deckhouse or Machinery Space grouping. There shall be no overlap of one group into another group's area to complete engineering work scope.,

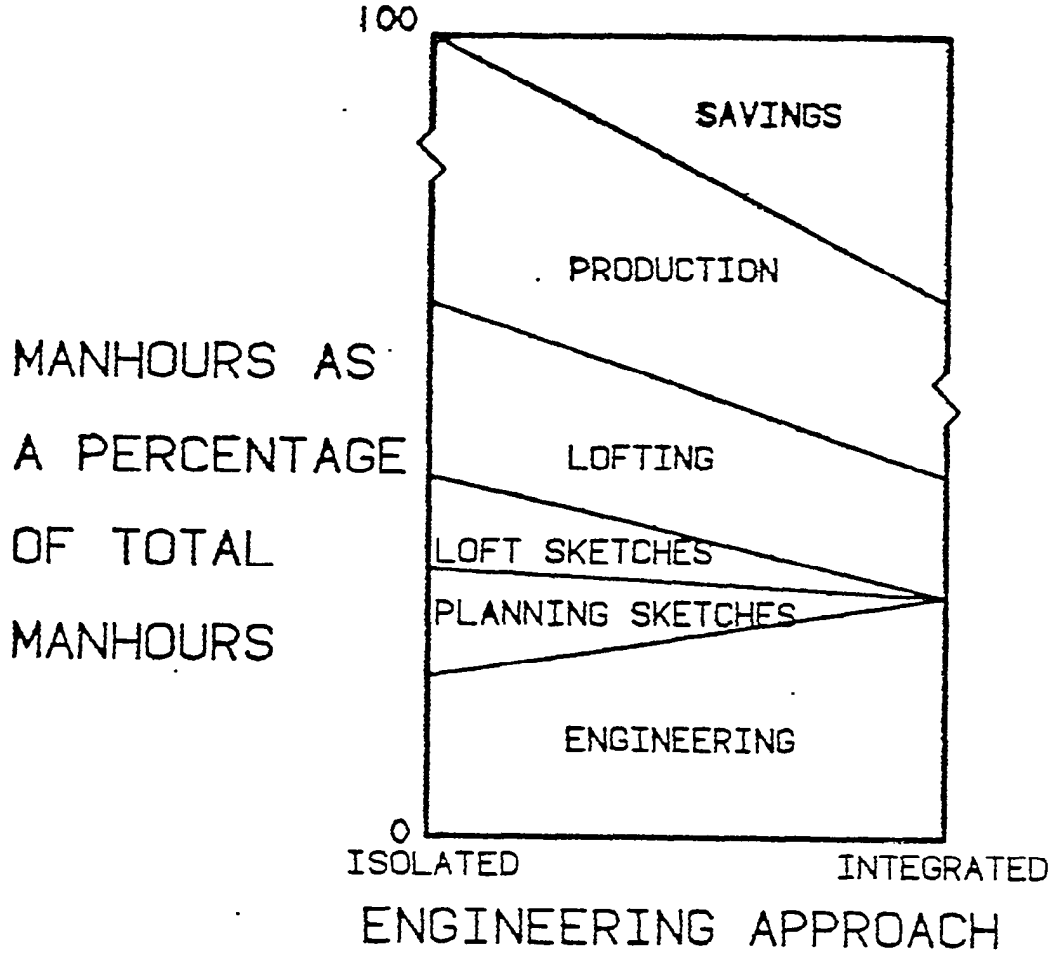


FIGURE 12 - OVERALL PRODUCTIVITY BENEFIT OF ENGINEERING FOR ZONE CONSTRUCTION

4.0 ENGINEERING ORGANIZATION FOR ZONE CONSTRUCTION

Organizational Theory has steadily developed along with the better understanding of human relations, motivation and worklife sciences. That this is so, is clear from a review of any bibliography on the subject of organization. It is not the intent to describe or recommend any of the theories, especially as the very foundations have been discredited in recent books about the most successfully operated U. S. companies (5) and future trends (6). What will be discussed is the basic organizational requirements for a shipyard engineering department. A number of papers and reports (7, 8, 9 and 10) touch on engineering organization, but only the later ones do so in any depth or cover the reasons for the differences. Books on general technical or engineering management (11, 12 and 1.3) describe some organizational aspects which can be helpful when examining shipyard engineering organization. The more recent papers and reports on advanced shipbuilding technology all contain three basic principles for shipyard engineering organization, namely;

1. Shipyard engineering should be divided into BASIC DESIGN and PRODUCT ENGINEERING. The meaning of this breakdown can be seen in Figure 13.

2. Engineering information should be presented in the simplest and most effective manner.

3. Engineering information should be developed to transmit only the information needed by one or more workers at a specific work station to perform the work at that work station.

To these three should be added a fourth, namely;

4. Engineering and planning are synonymous and the Product Engineering Section should prepare all planning material, such as lofting, N/C processing data, pipe sketches, instruction sheets.

The reasons for this additional principle should be obvious to the readers of this paper. It connects together the logical sequencing of the same data and with the increasing use of computers and software for CAD/CAM, it is possible to generate all the planning material as a natural fallout from the engineering data base.

Before proceeding, it is necessary to review some of the well known organizational structures. These include:

- Function
- Product
- Process
- Customer
- Matrix

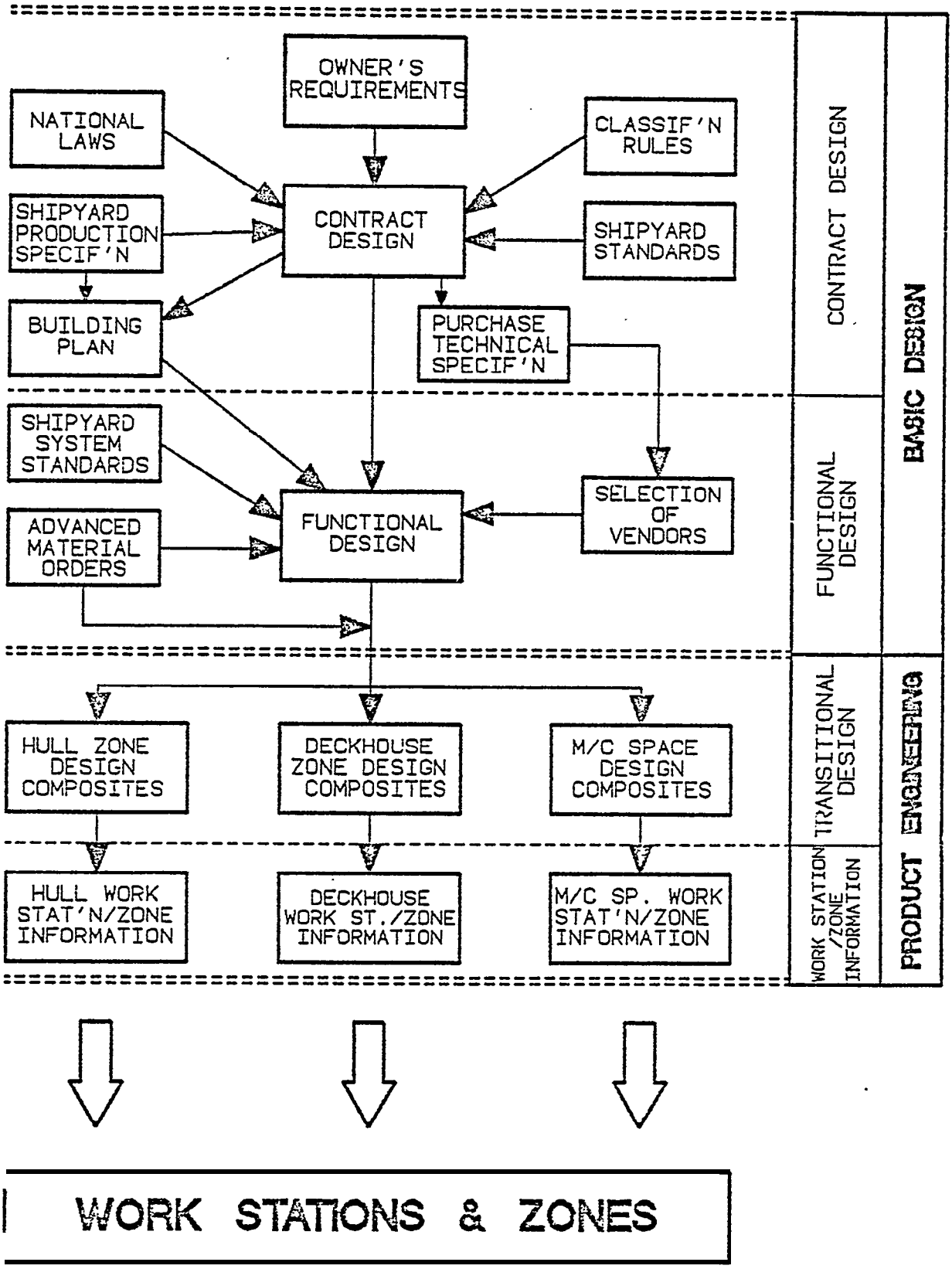


FIGURE 13 - FLOW OF DESIGN AND ENGINEERING INFORMATION

A Functional Organization is separated into major departments on the basis of function, such as Production, Engineering, Marketing, Finance, etc. This is the most common type of organization structure, as most people are educated and trained by function, and also organizations tend to copy other organizations. Such an organizational structure is shown in Figure 14.

The Product Organization is divided into divisions on the basis of major products, such as cars, trucks and tractors. Figure 15 shows a typical Product Organization. Product Organization has been used for the Product division of many large manufacturing companies.

Some manufacturing companies have found it beneficial to use an organization structure which fits in with the various processes through which their work moves, thus the name Process Organization for which a typical structure is shown in Figure 16.

Service companies often utilize a Customer organization structure. This type of structure is suited to sales oriented divisions or departments such as Marketing. A typical organization is shown in Figure 17. The usual reason for adopting this type of organization structure is to ensure that the needs of each customer are more than adequately met, and to give the appearance of special individual attention.

The Matrix Organization structure, which is shown in Figure 18, developed from the attempt to combine the benefits of more than one of the above types. This type of organization was utilized extensively by defense contractors. In its most common form, the Matrix organization provides the manager with the benefits of both the function and product (project) organization types.

The most recent trend is for shipyards to utilize the Product organization structure, but with the product being main zones of each ship. Obviously, the most benefit will result if all departments are organized in the same way. Much of the current problems are due to the fact that departments within the same shipyard have different organization structures, and the resulting mismatch of personnel in them. For example, it is not uncommon to find engineering functionally organized, purchasing product organized, planning process organized, and production functionally organized. This has to be changed to achieve high productivity shipbuilding. It is also necessary for all departments to be organized in the best way to support the production department.

The MarAd/SNAME sponsored IHI Shipbuilding Technology books lead from Outfit Planning to Design for Zone Outfitting. They develop a very specific approach to engineering organization which basically follows their overall

production organization. This is shown in Figure 19. Figure 20 shows a typical U. S. shipyard engineering department organization and Figure 21 the same for a British shipyard. It is interesting to note that the British organization is basically a two zone type. The Ship section handles and integrates everything outside of the machinery space, which is handled by the Machinery section. However, Electrical is still handled for the total ship. This approach is also used by at least one of the successful, large Japanese shipbuilders. However, in the British shipyard, even though engineering was somewhat product (zone) organized', the Production department was still functionally (craft) organized. The U. S. shipyard engineering organization is functionally organized with the different disciplines working in all areas. As such, it has little to recommend it for improved shipbuilding technology.

Therefore, what should be the organizational structure for the future in U. S. shipyards? It is suggested that it should not be the MarAd/SNAME IHI type. This is because the IHI approach is not "pure" in that it mixes organization types such as functional, product and process structure with zones. This can be seen from Figure 22 which shows that even though Hull Block Construction, Painting and Electrical are involved in all three zones, they are organized independently, and in a different way to the desired zone

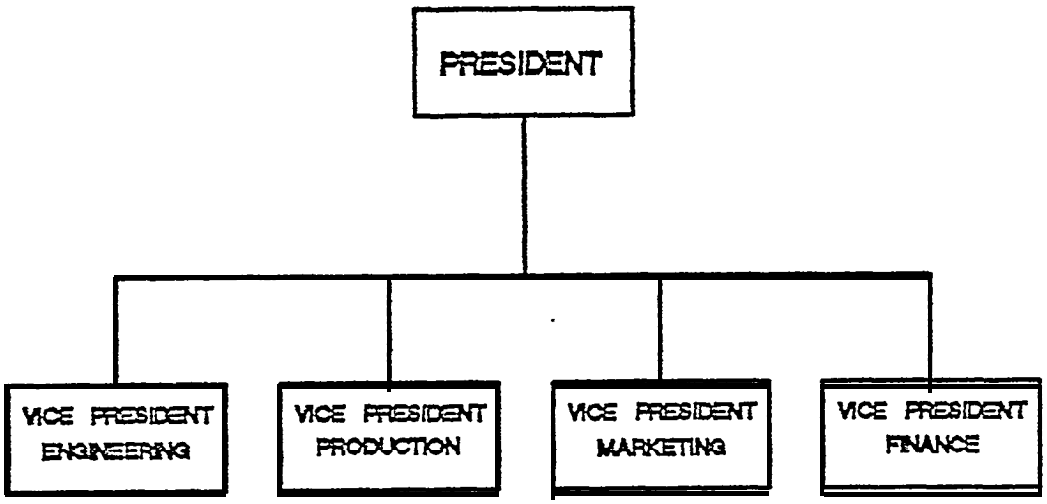


FIGURE 14 - FUNCTIONAL ORGANIZATION STRUCTURE

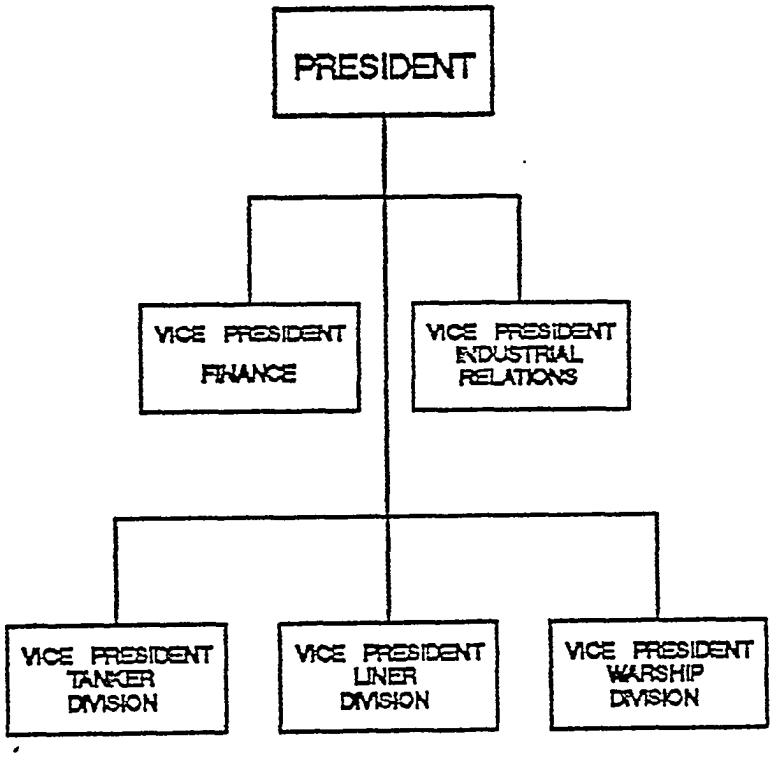


FIGURE 15 - PRODUCT ORGANIZATION STRUCTURE

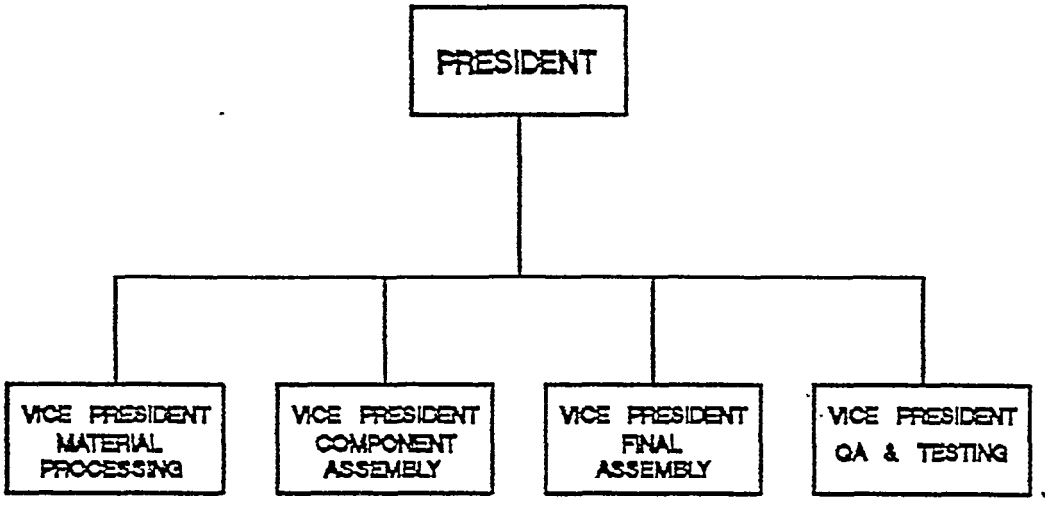


FIGURE 16 - PROCESS ORGANIZATION STRUCTURE

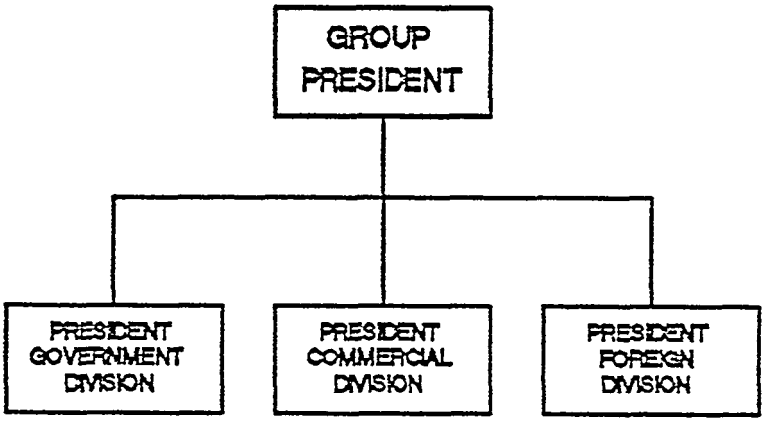


FIGURE 17 - CUSTOMER ORGANIZATION STRUCTURE

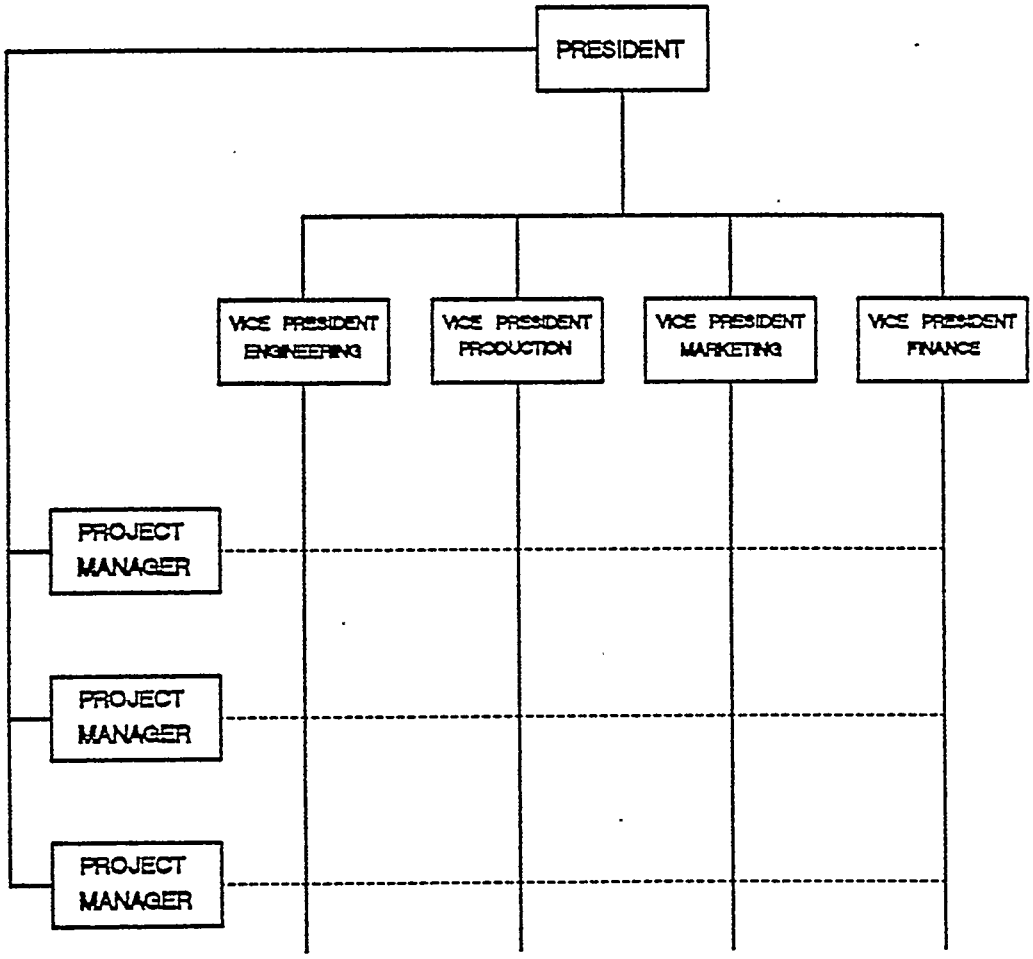


FIGURE 18 - MATRIX ORGANIZATION STRUCTURE

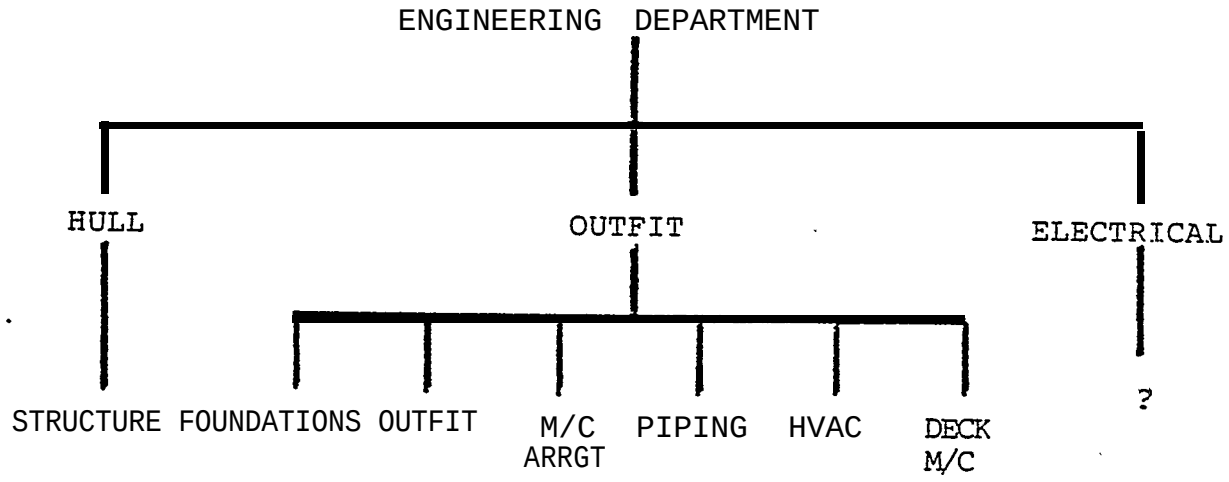


FIGURE 19 - MARAD/SNAME/IHI ENGINEERING ORGANIZATION

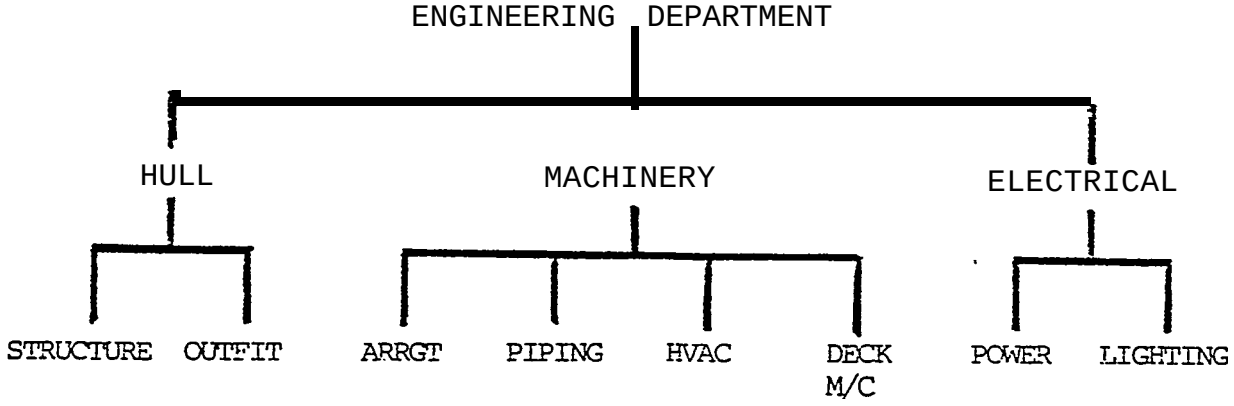


FIGURE 20 - TYPICAL U.S. ENGINEERING ORGANIZATION

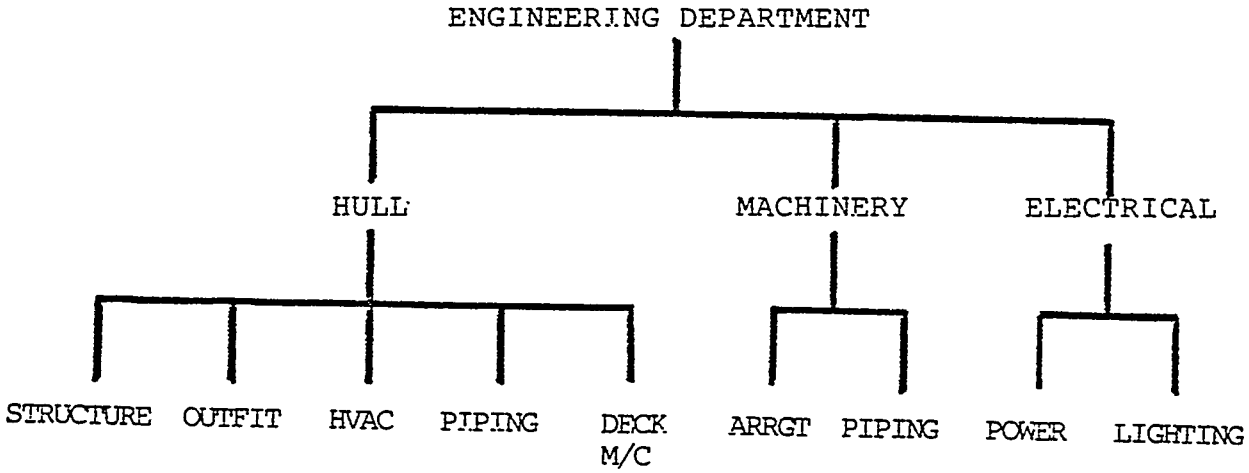


FIGURE 21 - TYPICAL BRITISH ENGINEERING ORGANIZATION.

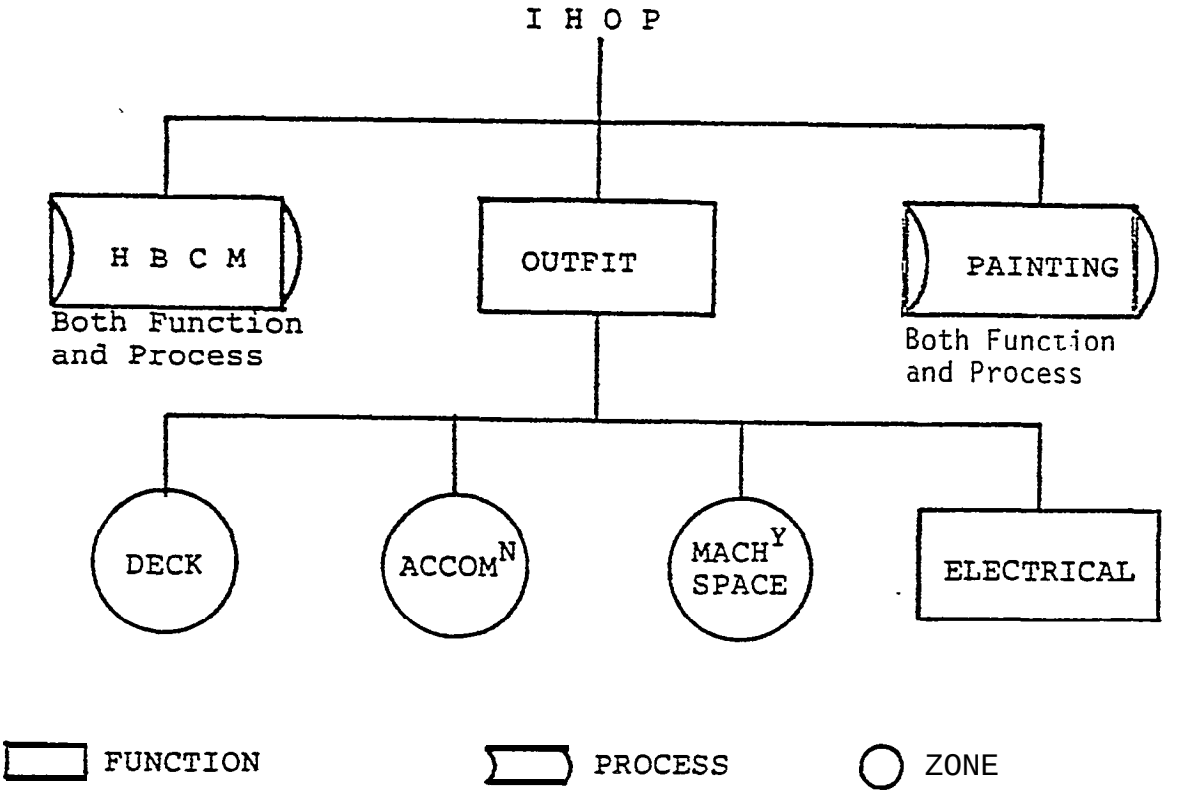


FIGURE 22 I H 0 P ORGANIZATION

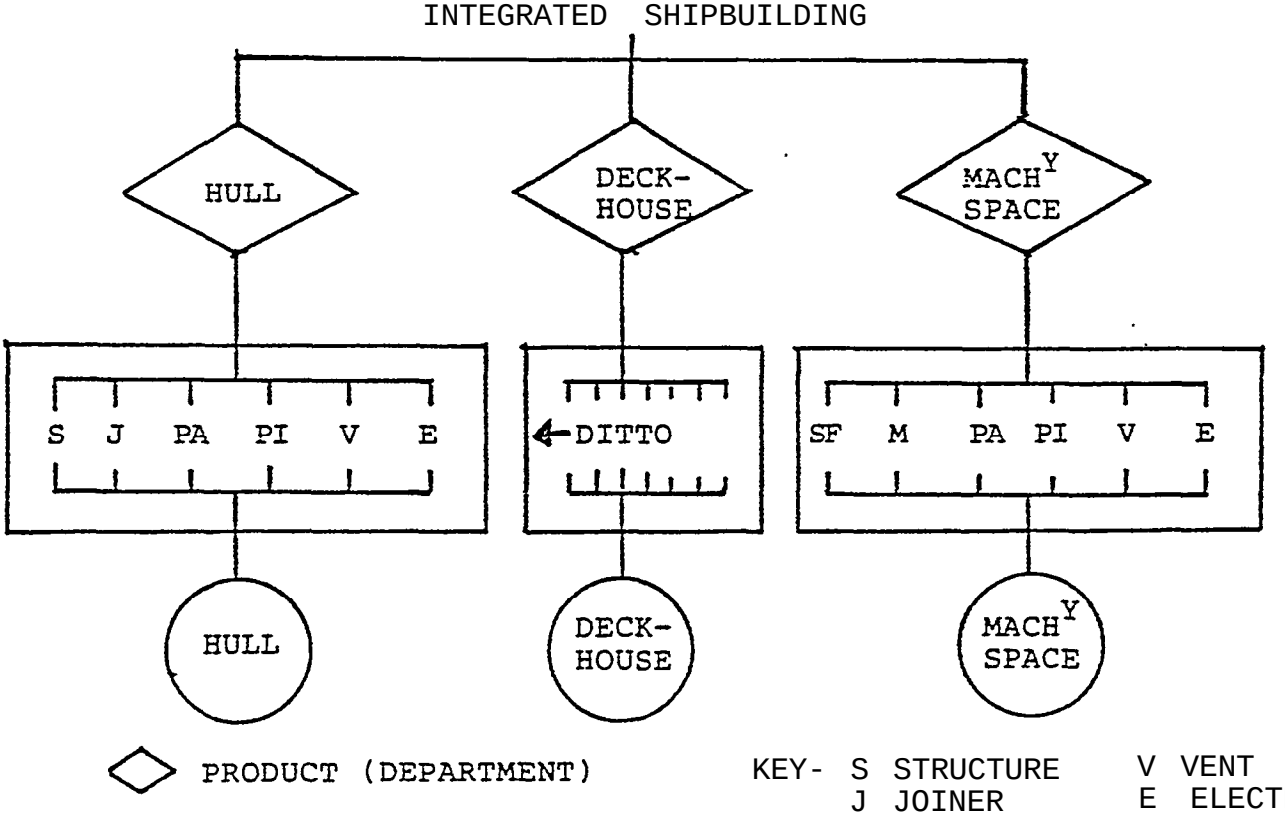


FIGURE 23 SUGGESTED ORGANIZATION FOR ZONE SHIPBUILDING

treatment of outfit. It can also be seen that Electrical, which is a function, is treated at the same level as the zones giving the D-A-M-E approach to outfitting. The inclusion of the "E" for Electrical has no organizational basis for being linked in this way to the three zones. It is suggested that it is done simply because of tradition in some Japanese shipyards. In order to develop an engineering organization, it is necessary to first develop the production organization with which it must blend. For this reason, a hypothetical production organization is shown in Figure 23. It can be seen that there is no incompatible mixing of organization structures, and that it is based on a three zone concept, namely; Hull, Deckhouse, and Machinery Space. Each zone covers a basic product even though each product is constructed from similar interim products. There is duplication of crafts within the three departments which is beneficial as long as there is a backlog of work to keep them all busy, and could lead to a restructuring of crafts in the future to improve their total performance in leaner and more competitive times.

It is obvious that an organization cannot be designed is the function of the parts are undecided. Therefore, the first step in engineering organization design is to establish the objectives of the Engineering Organization. This will depend on whether or not any part of the design and engineering will be performed by marine design consultants.

Based on the proposed Engineering for Ship Production approach, the objectives for a complete in-house engineering department include:

BASIC DESIGN

- o Perform concept, preliminary and contract design
- o Provide technical data for estimating and planning
- o Provide all design support for new ship construction
- o Provide Production Engineering
- o Prepare all design drawings through key drawings and diagrammatic phase
- o Prepare weight calculations
- o Provide Systems Engineering
- o MEET ALL ACCEPTED SCHEDULES

PRODUCT ENGINEERING

- o Organize to best support Integrated Shipbuilding
- o Prepare drawings, material lists, lofting, layouts, pipe assembly drawings and other Production required information
- o Perform configuration control of all engineering information
- o Provide engineering liaison to Production Department
- o MEET ALL ACCEPTED SCHEDULES

For an Engineering Department using a Marine Design Consultant to prepare both the design and the working drawings, the objectives of the in-house Engineering Department include:

BASIC DESIGN

- o Provide overall design leadership and direction
- o Provide production oriented design requirements
- o Provide continuous monitoring of project for unique production methods and facility involved
- o MEET ALL ACCEPTED WORK SCHEDULES

PRODUCT ENGINEERING

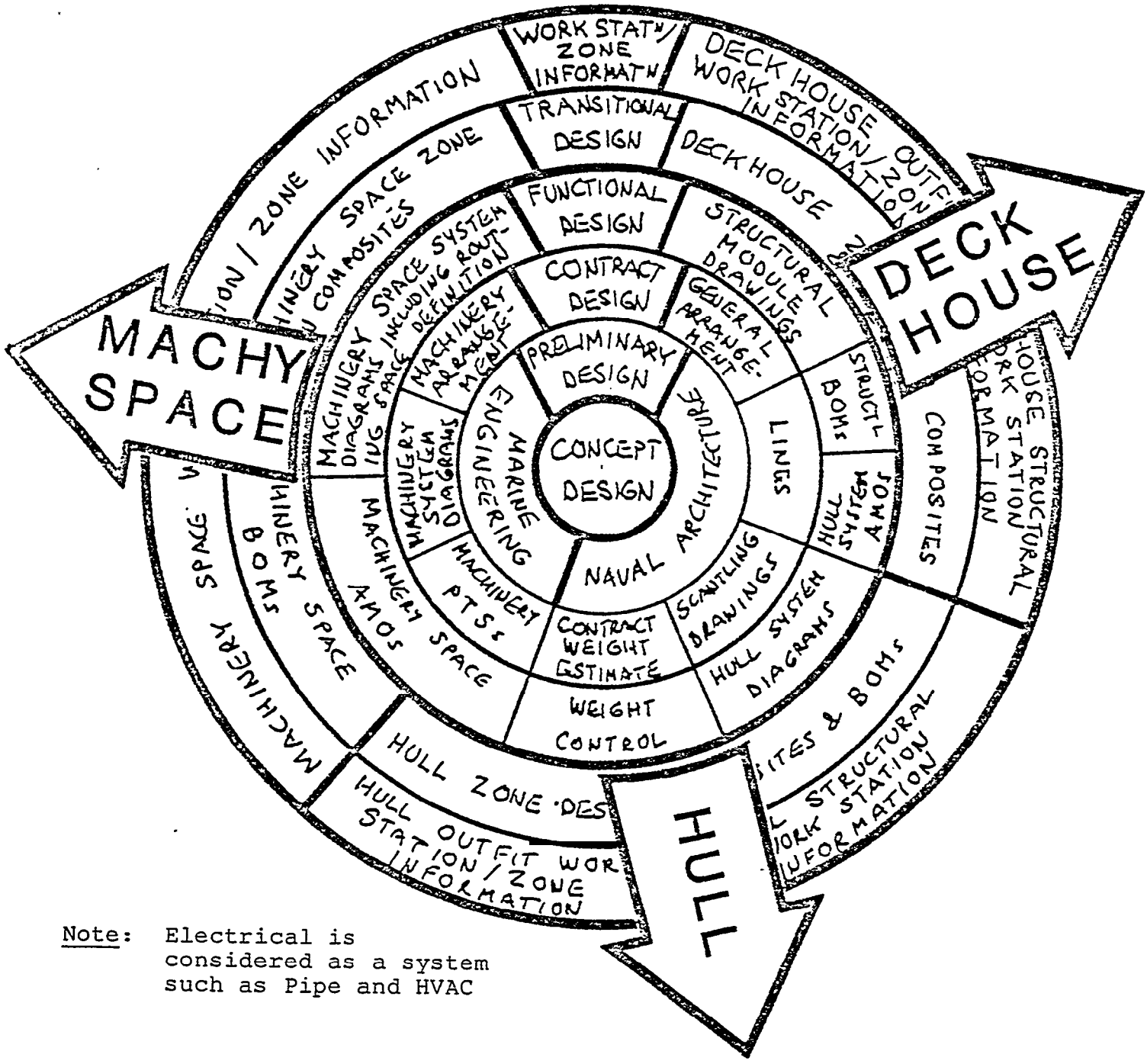
- o Organize to best, support Integrated Shipbuilding
- o Provide overall engineering leadership and direction
- o Ensure engineering is developed in the way desired for shipyard rather than what the consultant wants to do'
- o Prepare lofting, pipe assembly drawings, layouts, etc.
- o Prepare the technical information to complete work packages required by Production Department
- o Provide engineering liaison to Production Department
- o MEET ALL ACCEPTED WORK SCHEDULES

In both cases, the objectives should be reviewed regularly to enable a self-improving capability to flourish.

It has already been stated that the engineering organization should be compatible with the production organization. Actually, this is only necessary for the Product Engineering section. The Basic Design section can be functionally organized if it best suits its purpose. The

expanding data base concept (14) logically loads to the organization of the Product Engineering Section as three groups, namely; Hull, Deckhouse and Machinery Space. This is shown conceptually in Figure 24. With such an organization structure, no group is dependent on another group to complete their work, provide data or have another group check their work for interferences.

As an aid for developing a suitable Product Engineering organization, it is worthwhile to construct an Engineering Functi-Zone matrix such as Figure 25. Such a matrix, the different product engineering needs for the three zones can be determined. It can be seen that the Hull and deckhouse zones require the same functions, although the application will be different. However, the functions and application for the machinery space are quite different, being for a power plant rather than a distribution or service system. For this reason, it is proposed that product engineering be organized as three groups, namely Hull, Deckhouse and Machinery Space. Each group would consist of designers and some drafters experienced in their zone area who would be supplemented by drafters from a common drafter pool as the work required. Such an organization is shown in Figure 26. It is believed that U. S. shipyards would find it easier to change to this type of engineering organization than to the MarAd/SNAME IHI type.



Note: Electrical is considered as a system such as Pipe and HVAC

FIGURE 24 - BASIS FOR ENGINEERING SECTIONS
BASED ON EXPANDING COMMON DATA BASE

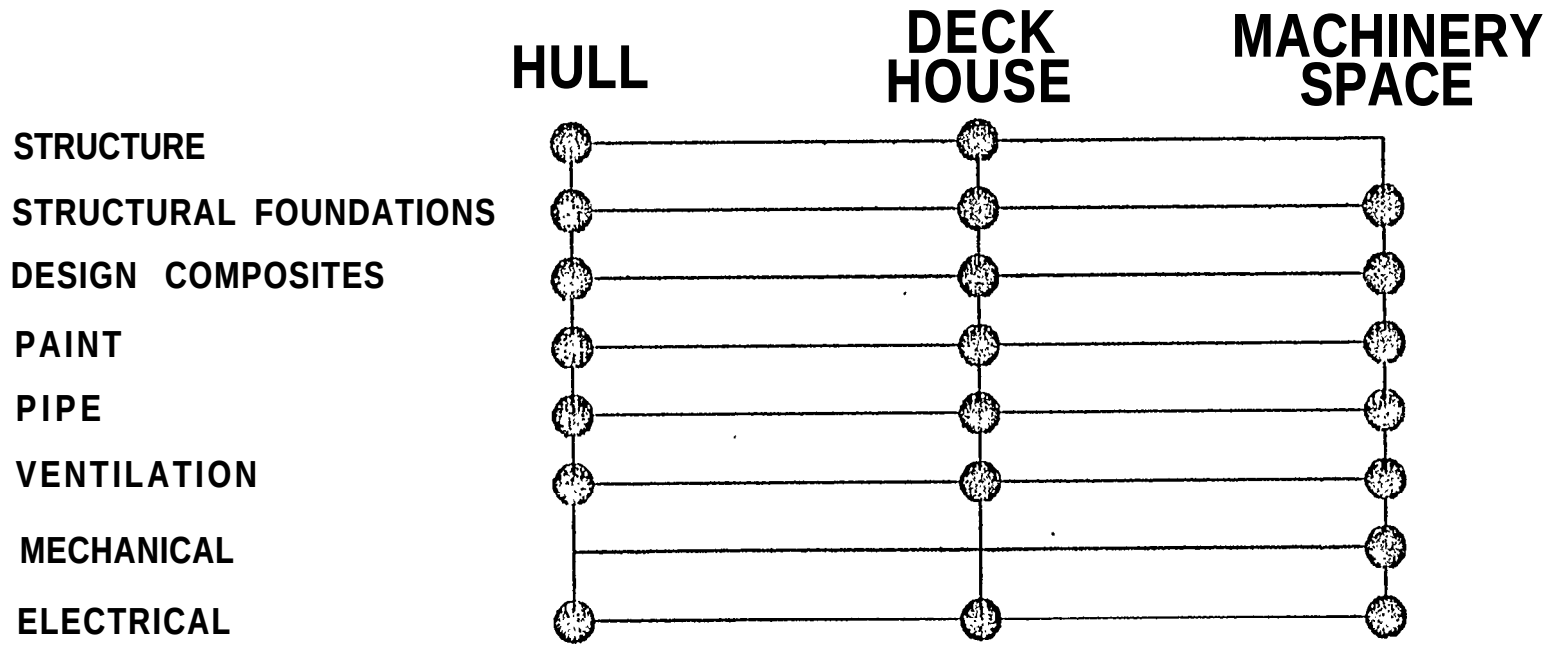


FIGURE 25 - PRODUCT ENGINEERING FUNCTION/ZONE MATRIX

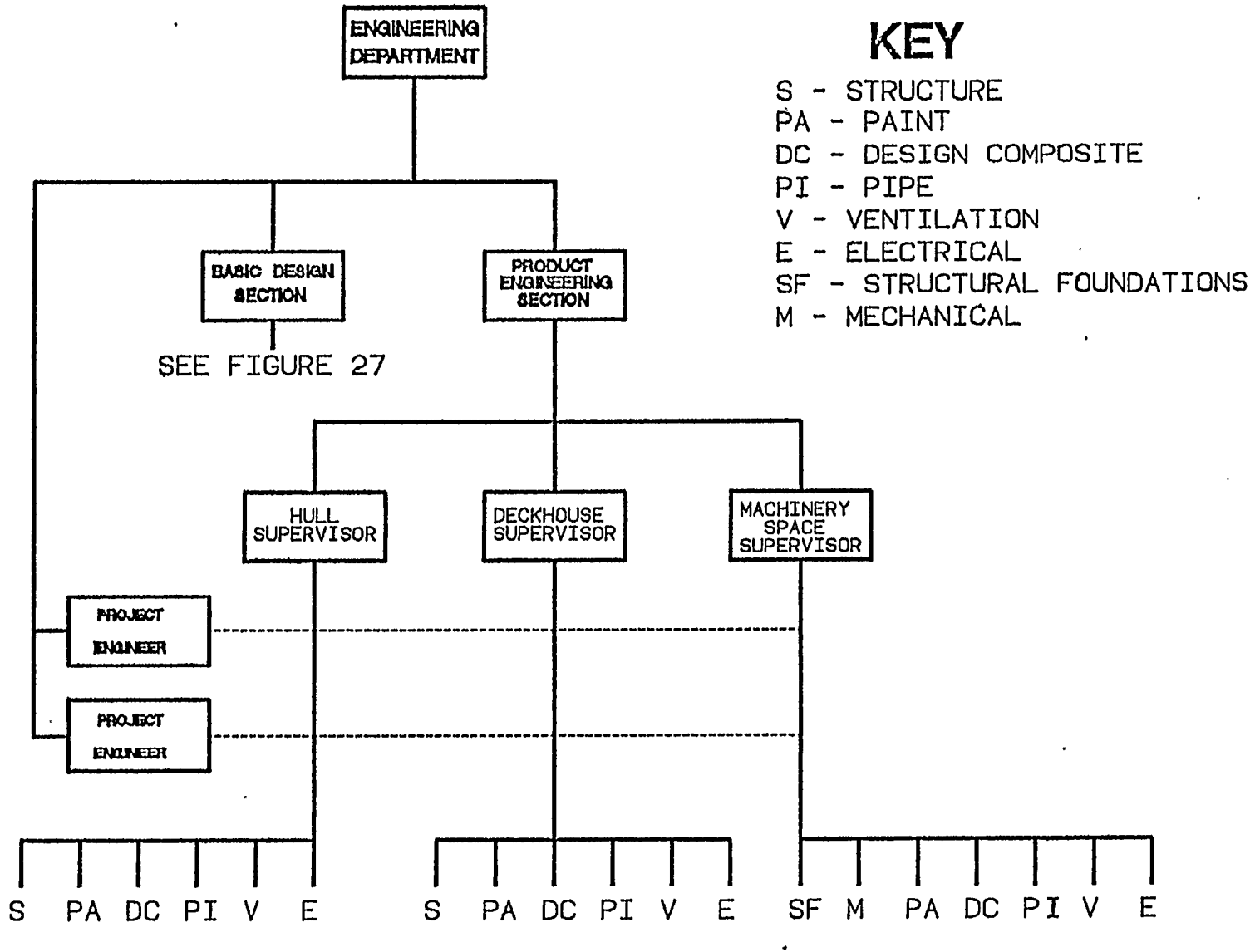


FIGURE 26 - ENGINEERING ORGANIZATION FOR ZONE CONSTRUCTION

All engineers, except those in management, liaison or those being trained, will be in the Basic Design section. The positioning of engineers in the production departments at all levels from department to work station has been shown by the Japanese to lead to significant benefits due to maintaining a high technology level in production and promoting superior communication. In U. S. shipyards the duties and responsibilities of such engineers could be equivalent to' those in Japanese shipyards, where they are involved in planning, scheduling, material flow, accuracy control and manning requirements for their area of responsibility, or they may be restricted to the usual U. S. role of engineering liaison. in any case, such an approach would appear to be worthwhile for U. S. shipyards, as it would transfer the higher technical base out into the production department, and enable the engineers to gain production experience and better understanding of the production department's needs and problems by engineering.

A suitable organization structure for the Basic Design section in the hypothetical integrated shipyard is shown in Figure 27. It is a combined functional/matrix structure. The functions are the usual Naval Architecture, Marine and Electrical Engineering, whereas the matrix roles are for the Production and Systems Engineering input to the three functional roles. The Production and Systems Engineers are

directly responsible to the Basic Design Manager to direct, educate, train and monitor the functional engineers in production oriented design and systems integration respectively.

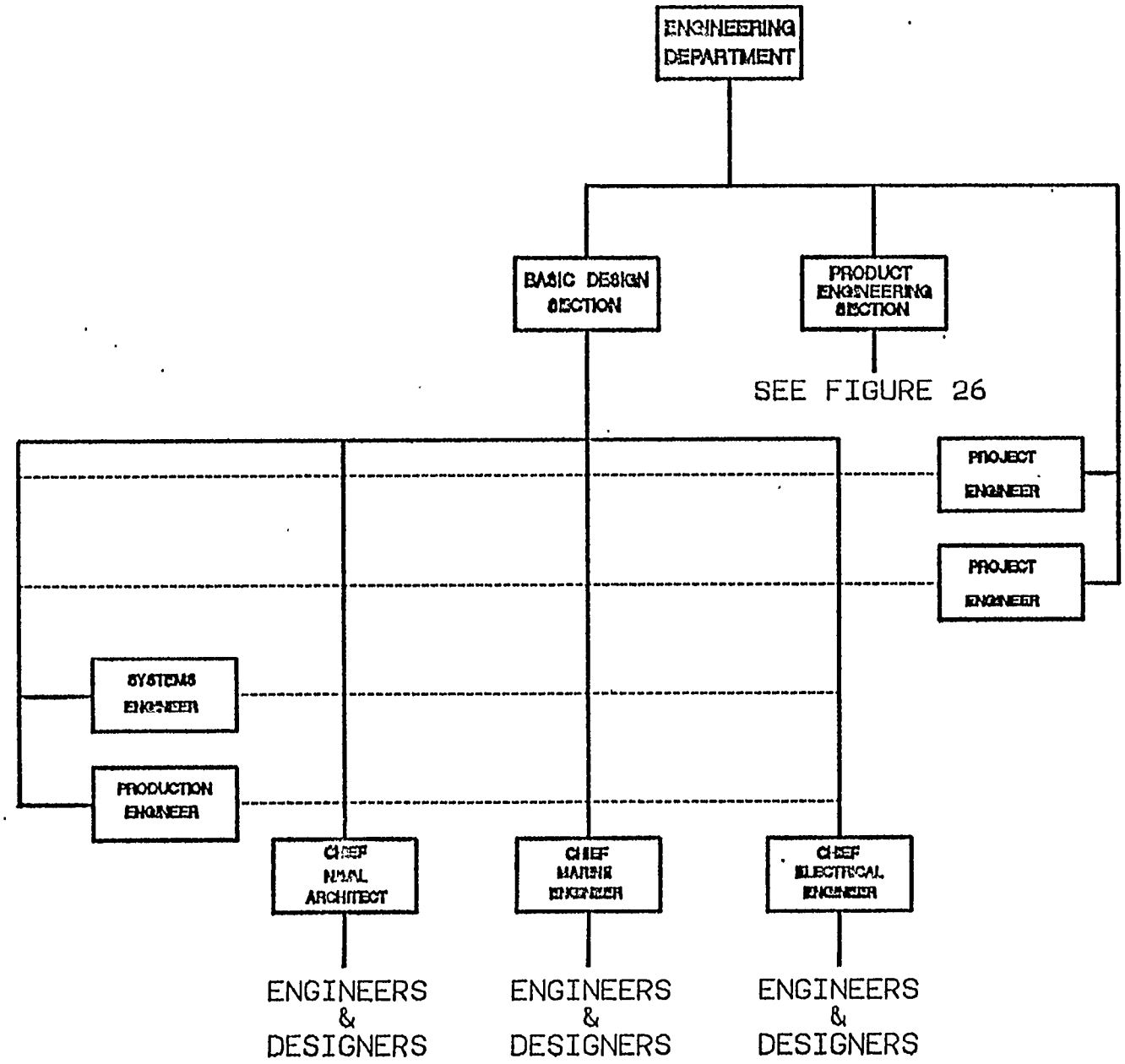


FIGURE 27 - BASIC DESIGN ORGANIZATION

5.0 ENGINEERING STAFFING FOR ZONE CONSTRUCTION

The staffing of the organization is one of the most important factors affecting its success. Even the best organization will not accomplish its goals effectively and efficiently if it is not staffed with the correct number of people with the correct balance of education, training and experience. This is equally true of all departments in a shipyard, not only engineering. In order for the modern shipbuilding methods to be accepted and competently used, it is necessary to upgrade the technical and educational level of all shipyard managers and supervisors.

It is often stated (15, 16) that the U. S. engineering problem is due to an inadequate number of engineers directly employed by the shipbuilding industry. While it is true that more engineers would give the engineering managers more. resources to accomplish the work, it may simply mean more engineers preparing the work in the same outdated inefficient way. It would obviously increase the cost of engineering so there would need to be a resulting greater reduction in production manhours for it to make sense.

Table 4 below gives the ratio of graduate engineers to total engineers in the U. S. aircraft and shipbuilding industry as wll as the same ratio for British and Japanese shipyards.

TABLE 4 - GRADUATE ENGINEERS/1000 EMPLOYEES

U. S. Aircraft Industry	10
U. S. Shipbuilding	5
British Shipbuilding	6
Japanese Shipbuilding	52

The SNAME SP-2 Panel on Education and Training issued a report on "Curricular Needs of Shipyard Professionals" in June, 1984. This report shows that for 10 U. S. shipyards, the ratio of Graduate Engineers per 1000 employees was actually 14. Before it is concluded that this means that everything is therefore fine in the industry, it should be noted that the same report states that only 20 percent of the engineers were naval architects and marine engineers. The report states, "this means that the other 80 percent of the entry level technologists most likely have not been exposed to the shipbuilding industry prior to graduation."

Table 5 (from reference 17) shows the ratio for both graduate engineers and designers for British shipbuilding. It can be seen that the number of graduate engineers has fallen from 13 to 6 per 1000 employees since 1965 to 1974. The total number of technical staff has, however, remained constant at about 60 per 1000 employees. The natural question is does the shipbuilding industry really only require half the number of engineers that are necessary for the aircraft industry? Japanese experience shows a significantly higher

TABLE 5 Technologist & Technician Statistics for Shipbuilding Industry

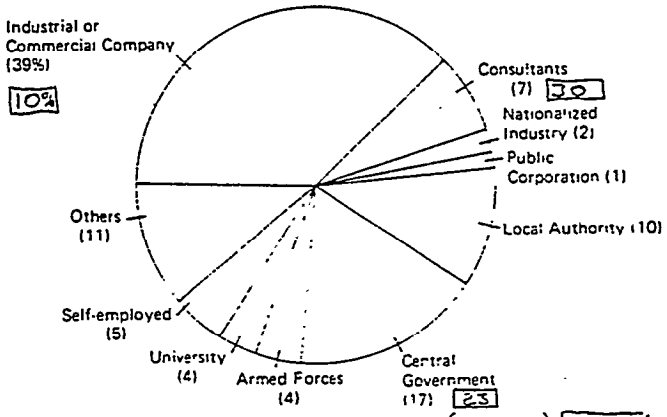
	Numbers Employed						
Occupation	1965	1967	1968	1969	1970	1971	1974
Qualified Scientists & Engineers	1704	1599	957	771	545	445	598
Design & Other Draughtsmen	3863	3755	4084	3767	3796	3284	3473
Other Technicians	2203	2092	2336	2663	2214	1887	2071
Total Technicians	6140	5847	6420	6430	6010	5171	5544
Total of All Employees	130,059	128,649	121,454	120,196	122,250	115,802	100,886
QSE/Total Employees	1·32%	1·24%	0·79%	0·64%	0·45%	0·38%	0·59%
Total Tech./Total Employees	4·52%	4·54%	5·29%	5·35%	4·92%	6·00%	5·50%
(QSE + Total Tech)/Total Employees	5·84%	5·78%	6·08%	5·99%	5·37%	6·37%	6·09%
Total Tech/QSE	3·43/1	3·66/1	6·71/1	8·34/1	11·03/1	11·62/1	9·27/1
Draughtsmen/Total Tech	62·85%	64·22%	63·61%	58·58%	63·16%	63·51%	62·64%

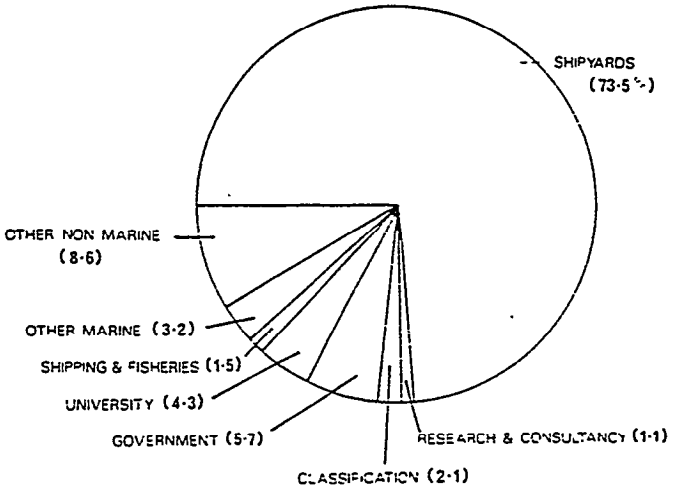
Notes: Qualified Scientists and Engineers (QSE) include all employees who hold a university degree or equivalent, or are corporate members of appropriate professional institutions.
Prior to 1968 the IINC was included in the definition of QSE but was subsequently excluded.
Prior to 1960 tracers were included with draughtsmen.

ratio. However, it is necessary to look at the Japanese ratio closer to make sense of the comparison. Japanese graduates are of two types; the first is similar to U. S. and European engineering graduates, and the second is similar to a technical college student. The second type is not included in the U. S. or British ratios in Table 4. Nevertheless, it is probable that the Japanese ratio for the similar engineering graduates would be about 20 per 1000 employees, still significantly higher than the U. S. and Britain. It is suggested that this higher number of technically educated people in the shipyards is a major reason for their success in shipbuilding and advanced shipbuilding technology.

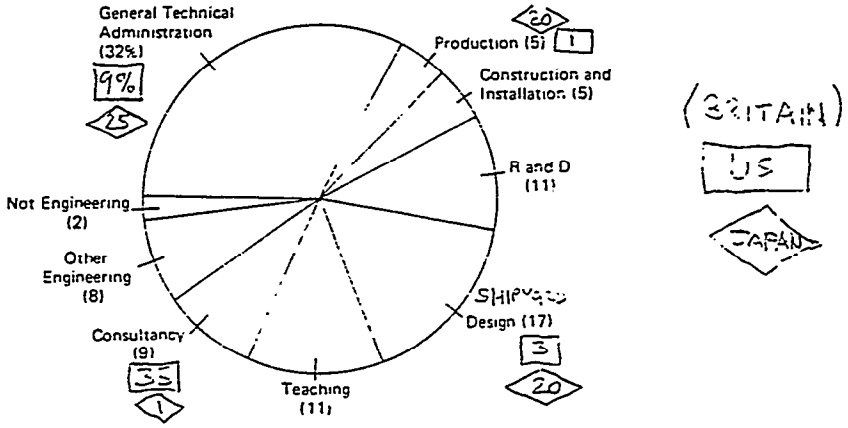
Figure 28 shows the employers of and occupation of Naval Architects in the U. S., Britain and Japan based on Figures from reference (18). Its message is clear! The U. S. needs more Naval Architects (and other engineers) in the shipyards. How can this be justified, let alone accomplished in a contracting industry? It must be by training engineers in the advanced shipbuilding technology and allowing them to practice the new way in both engineering and the other shipyard departments which must improve their performance to accomplish the goal of higher productivity and shorter building cycles for future ships. It is understandable that in the work scarce and competitive situation that U. S. shipbuilding is

currently facing, it may be difficult for shipbuilding management to take such steps. However, it is probable that those who survive the current crisis will be the ones who try innovative solutions to the current problems.





Employers of Naval Architects in Japan



Occupation of Naval Architects by Type of Work

FIGURE 28 - NAVAL ARCHITECTS, EMPLOYERS & OCCUPATIONS

6.0 ENGINEERING TRAINING FOR ZONE CONSTRUCTION

Training is another major factor affecting the outcome of any organization. When it is realized that well planned and practical apprenticeships are almost non-existent in the U. S. shipbuilding industry, and that most engineers and designers are left to "learn the hard way", it is not surprising that it is close to the bottom of the shipbuilding technology ladder. It is essential for the U. S. shipbuilding industry to upgrade the knowledge level of shipyard employees. It will be futile to introduce advanced technology into shipyards if they are staffed by low level educated and trained personnel.

As it is obvious that there is not an abundance of engineering personnel already practicing the -proposed Engineering for Zone Construction, it will be necessary to educate and train existing and new shipyard design and engineering department employees as well as those of marine design consultants in the methods and procedures to be used.

Another problem that must be recognized is that todays shipbuilding management, including engineering, has been trained in the traditional ways and are often too busy dealing with everyday problems to take time to learn and completely understand new ways! In such an environment, new

graduates educated and others trained in advanced shipbuilding technology will be frustrated by the apparent. lack of interest shown by these busy managers.

Therefore, it is suggested that shipyards, either individually or in association with other shipyards and/or universities and technical colleges, offer the education and training that is required to provide the level of advanced shipbuilding technology to increase the possibility of successful operation in the near and far future.

The subject of training for any industry is complex and large. It is not even suggested that it can be covered in an engineering management paper. It was necessary to briefly discuss it in order to draw attention to the need for a well planned effort by each shipyard and even by the industry. Until such a system is in use, it behooves each engineer and designer to plan their own training.

With this in mind, a recommended reading reference on this matter is a recent paper by Dr. B. N. Baxter (19). Figure 29 which is from a paper by G. Sivewright in reference (21) indicates the thought and planning that must be expended to develop a successful program as well as guide the self trainer on areas to be developed to be a successful practitioner of Engineering for Zone Construction. The Common Core Basic Training programs that were established by the British

Shipbuilders Training Board for various professions in shipbuilding (20), are also useful guides. Another reference worthy of reading is the RINA Symposium on the Training for Naval Architecture and Ocean Engineering (21).

It should be remembered that education and training are the food and exercise essential for the healthy and sustained life of any business. The shipbuilding industry in the U. S. will not become competitive if left undernourished and unfit.

TECHNICIAN ENGINEERS AND TECHNICIANS - DIAGRAM OF TRAINING

Bridging Training Programmes contain elements of general and objective training to meet individual needs.

ARROW "A" – Trainee craftsmen selected as potential technicians to start general training

ARROW "B" – Trainee craftsmen during P.E. selected as potential technicians to start bridging training programme.

ARROW "C" – New entry adults and craftsmen selected as potential technicians or draughtsmen to start bridging training programme.

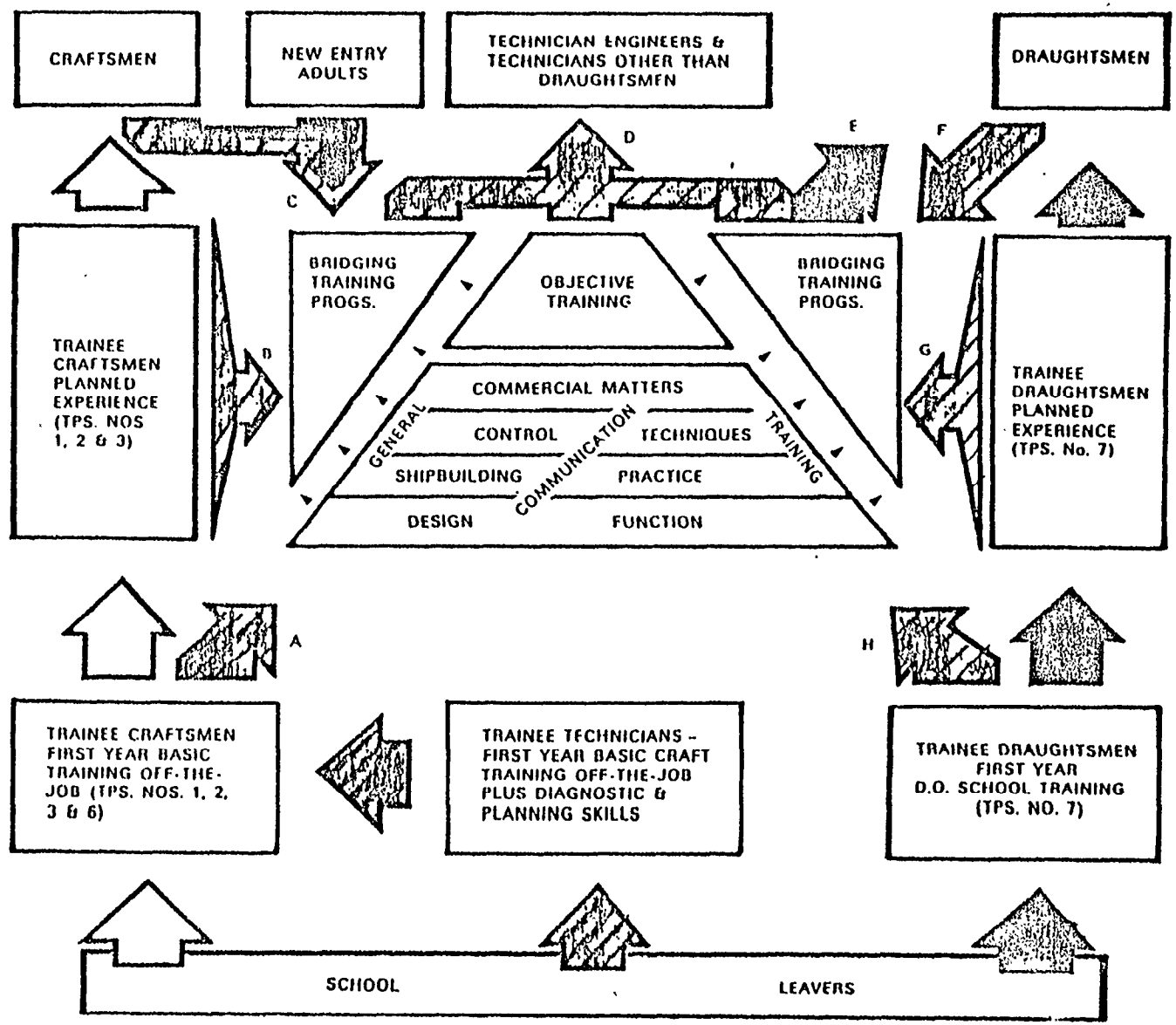
ARROW "D" – Trainee technicians complete technician training

ARROW "E" – Trainee draughtsmen recruited from craftsmen or new entry adults complete bridging training programme

ARROW "F" – Trainee draughtsmen start other technician job training programme.

ARROW "G" – Trainee draughtsmen during P.E selected for other technician jobs to start bridging training programme

ARROW "H" – Trainee draughtsmen on completion of first year training selected for other technician jobs start general training.



COLOUR KEY

Trainee Draughtsmen

Trainee Craftsmen

Trainee Technician Engineers and Technicians

FIGURE 29 - BRITISH SHIPBUILDING TRAINING PROGRAM

7.0 ENGINEERING PLANNING FOR ZONE CONSTUCTION

Engineering Planning for Zone Construction requires to be managed just like any other worthwhile activity. However, the Zone approach to engineering can reduce the complexity of management in the same way it simplified planning and scheduling. This is possible because of the following factors:

- o Elimination of duplication of effort and data.
- o Organized to suit zones.
- o Integration of lofting and planning with engineering.
- o Material designed, selected, procured and scheduled by zones.
- o All engineering disciplines working on each zone at the same time.
- o No issue of engineering information before it is completed for all disciplines for each zone.

As in any business, assuming an effective organization is in place, planning, scheduling and control are the keys to success. Without them, the basic concepts of the modern integrated 'shipyard would be unworkable. Therefore, it is likely that in a modern shipyard, an integrated management information system will be used for these functions. In such 2 case, it is necessary for engineering to prepare the information used by the system. Even with such an integrated system, it is probable that engineering prepares two schedules which are unique to its function and they are:

- o Drawing Schedule

  This schedule should list all product engineering drawings which are required to construct the ship. It should have an upper and lower row for each entry in which scheduled and actual dates are listed respectively. Columns should be provided for dates for drawing start, completion, submitt21 to owner, classification and regulatory bodies, and issue. The drawing schedule is used for a number of purposes by the shipyard and others, such as an index of drawings and as a record of approval action. It should not be used to control or progress the project. The drawing schedule could be an automatic fallout from the integrated planning, scheduling and control system as all the information is in the common data base.

- o Purchase Specification Schedule

  This schedule is required by the shipyard as a means of approval control of major purchased equipment and machinery by the owner. It can also be used by the shipyard to record the status of activity on major equipment and machinery procurement. Again, it could be an automatic fallout from the integrated management system as all the required information would be in the common data base.

There are still many shipyards where the different departments plan, schedule and control independently! A major or key event schedule is used as the integrating document but it is difficult to keep up to date for changes in any of the independent systems.

The outcome is usually unreliable, confusing and an open invitation to conflict between the various departments. If an integrated system is not used, the engineering department must utilize a planning, scheduling and control system of its own. In this case, it is important that the output from this department system can be utilized by purchasing and production as input to their systems. The system must provide as a minimum the three basic decisions and the four feedbacks mentioned in Section 1.0 Introduction. The system should be simple to use. For example, it should accept employee timecard data without an preprocessing manipulation and minimum additional data.

Such 2 system was developed some years ago by the author and will be briefly discussed. It uses the initial planning, scheduling and budgeting information as the basis and requires only progress estimates in addition to the employees normal timecards. Even this can be eliminated by using completion of previously performed tasks as the performance efficiency. Figure 30 shows the report form that connects engineering, purchasing and production schedules together. It does not include purchase technical specifications. It is prepared to tie together issue dates for drawings and other engineering information to production and Bills of Material to purchasing. The report form is not used by engineering to progress or control the project. Figure 31 is the schedule and work assignment bar chart. The chart is produced from the initial schedule and budget information and is continuously updated.

It shows when each task is scheduled to be worked on, how many hours to be worked each day and scheduled issue. As each report is issued, it also shows actual time worked on each task. This prevents the deliberately misleading practice of starting and recording the start for a task on the scheduled day and then delaying any further work until later. It is also possible to show the various stages of work on a task, such as design calculations, drawing preparation, BOM preparation, checking, rework after checking, and rework after approval. By comparing the scheduled time against actual time for the last two items, an actual indication of the technical excellence, or otherwise, of the engineering department will be given.

PROJECT NO 123 ENGINEERING EXTERNAL DOCUMENT SCHEDULE AND RECORDING REPORT REPORT DATE 6-4-76

IDENT NO	TITLE		SKETCH OR DRAWING START	SKETCH OR DRAWING COMPLETION	DRAWING APPROVL	DWG ISSUG TO YARD	BOM TO PURCH	SHOP SKETCH TO YARD	N/C TAPE ISSUE TO YARD	PROCESS SHEET TO YARD
390-2100	LOWER FWD DEEP TK P	SCHD	1/ 5/76	1/30/76				3/26/76	4/23/76	4/23/76
	UNIT 3-90 SHOP SKETCH	ACTUAL	1/ 5/76	1/27/76				3/19/76	4/23/76	4/23/76
391-2100	LOWER FWD DEEP TK S	SCHD	12/20/75	1/30/76				3/26/76	4/23/76	4/23/76
	UNIT 3-91 SHOP SKETCH	ACTUAL	12/20/75	1/29/76				3/26/76	4/28/76	4/28/76
392-2100	UPPER FWD DEEP TK P	SCHD	1/ 5/76	1/30/76				3/26/76	4/23/76	4/23/76
	UNIT 3-92 SHOP SKETCH	ACTUAL	1/ 5/76	1/27/76				3/26/76	4/23/76	4/23/76
393-2100	UPPER FWD DEEP TK S	SCHD	1/19/76	2/ 6/76				4/ 2/76	4/30/76	4/30/76
	UNIT 3-93 SHOP SKETCH	ACTUAL	1/19/76	2/ 4/76				4/ 2/76	4/24/76	4/24/76
394-2100	LOWER ROW	SCHD	2/ 2/76	2/13/76				4/ 9/76	5/ 7/76	5/ 7/76
	UNIT 3-94 SHOP SKETCH	ACTUAL	2/ 2/76	2/13/76				4/ 2/76	5/ 7/76	5/ 7/76
395-2100	UPPER ROW	SCHD	2/ 2/76	2/13/76				4/ 9/76	5/ 7/76	5/ 7/76
	UNIT 3-95 SHOP SKETCH	ACTUAL	2/ 2/76	2/13/76				4/ 9/76	5/ 7/76	5/ 7/76
396-2100	FOCSLE	SCHD	1/26/76	2/20/76				4/16/76	5/14/76	5/14/76
	UNIT 3-96 SHOP SKETCH	ACTUAL	1/26/76	2/18/76				4/12/76	5/ 7/76	5/ 7/76
397-2100	DECKHOUSE	SCHD	1/19/76	2/20/76				4/16/76	5/14/76	5/14/76
	UNIT 3-97 SHOP SKETCH	ACTUAL	1/21/76	2/24/76				4/16/76	5/14/76	5/14/76
1-2401	RUDDER	SCHD	2/ 2/76	2/27/76	4/ 2/76	4/23/76	4/23/76		5/21/76	5/21/76
		ACTUAL	2/ 4/76	2/27/76	3/25/76	4/23/76	4/20/76		5/25/76	5/21/76
1-2402	RUDDER STOCK	SCHD	1/26/76	2/13/76	4/ 2/76	4/23/76	2/16/76			
		ACTUAL	1/26/76	2/13/76	3/25/76	4/16/76	2/16/76			
1-2403	RUDDER ARRANGEMENT	SCHD	1/12/76	1/30/76	4/ 2/76	4/23/76	2/16/76		6/25/76	6/25/76
		ACTUAL	1/ 5/76	1/28/76	3/25/76	4/16/76	2/16/76			
1-2501	MAST ARRG & DETAILS	SCHD	3/15/76	4/16/76	6/18/76	7/12/76	6/18/76		8/ 9/76	8/ 9/76
		ACTUAL	3/15/76	4/16/76						
1-2503	YARDS & STAFFS ARRG & DETAILS	SCHD	4/ 5/76	4/30/76	7/ 2/76	7/26/76	7/ 2/76			8/23/76
		ACTUAL	4/ 7/76	4/30/76						
1-2504	MISC DAVITS	SCHD	3/29/76	4/30/76	7/ 2/76	7/26/76	7/ 2/76			8/23/76
		ACTUAL	3/29/76	5/ 3/76						
1-3101	MOORING ARRANGEMENT	SCHD	3/22/76	4/23/76	6/25/76	7/19/76	6/25/76			8/16/76
		ACTUAL	3/18/76	4/21/76						

FIGURE 30

PROJECT NO 123 ENGINEERING WORK SCHEDULE AND RECORDING CHART REPORT DATE 5- 6 -73
PAGE 5

ANNUAL CALENDER DAYS 63

DATA NO	CHG NO	ISSUE DATE / EMPLOYEE NO	70 12MAR73 SMTWTFS	77	84 26MAR73 SMTWTFS	91	98 9APR73 SMTWTFS	105	112 23APR73 SMTWTFS	119	126 7MAY73 SMTWTFS	133	140 21MAY73 SMTWTFS	147	154 4JUN73 SMTWTFS	161
			19MAR73 SMTWTFS		2APR73 SMTWTFS		16APR73 SMTWTFS		30APR73 SMTWTFS		14MAY73 SMTWTFS		28MAY73 SMTWTFS		11JUN73 SMTWTFS	
1-3601	111	5-21-73	11111	11111	11111	11111					D		I			
			22222	22222	22222	22222					D					
											D					
		201060	46645	66442	88648	64438	48				D					
		237723	86448	48846	48848	68470	8				D					
											D					
	112				88888	88888	88888	88888			D					
											D					
		201060			2 24	2 445	4 42		24		D					
		237723			2 4	2 41	442		3 4		D					
		291061			44444	44444	44 44	64644	244		D					
											D					
	113								88888		D					
		157119							8888	8	D					
											D					
1-3602	111	5-28-73		88388	88888	88898	8883				D			I		
											D					
		237125		88484	8888 8	88888	4241				D					
											D					
	112					44444	44444	4444			D					
											D					
		291061				44444	44444	2424	4		D					
											D					
	113									88888	D					
		157119								8888	D					
											D					
1-3602	111	6-18-73						88888	88888	88888	D	888				I
											D					
		201060						88888	64888	888	D					
											D					
	112									44444	D	44444	44			
											D					
		291061								4466	D					
											D					
	113										D		888			
											D					
											D					

-374-

FIGURE 31

The program works back from the required issue date for engineering information allowing for approval times and determines days on which work must be done. If a start date is inputed, the number of hours required to be expended each day is also calculated and given. Otherwise the days are scheduled on the basis of an 8 hour day. The program adds up the scheduled hours to be worked each day and gives a total. Peaks and hollows in the daily work demand can be easily seen and adjustments made to even out the manning requirements. The program does not currently include an automatic resource allocation capability. Thus, the Schedule and Work Assignment Report shows the three basic data requirements. By processing time charged to each task from the employees' normal timecards, each issue of the report is an excellent visual aid to quickly show how well the schedule is being adhered to. Thus, the first feedback question can be answered. By incorporating estimated completion of each identified task, the program will develop data to answer the remaining three feedback questions, thus enabling analysis and resulting decision and action. This information is shown in the performance report such as Figure 32. It reports on the performance of the work compared to the budget and determines individual variance as well as total product variance. It also projects time required for completion of each task and total project, and indicates whether individual tasks can be done in time, with and without overtime. Therefore, the report clearly shows any task that is in trouble. This is again summarized for the total project as shown in Figure 33. The system therefore is capable of indicating any problems, such as delay and low performance and what is necessary to get back on schedule and improve performance.

These reports have been found to be adequate tools to enable a number of engineering projects to be successfully managed and the necessary schedule data communicated to purchasing and production departments. However, it is restated that to achieve the desired high productivity, short building cycle shipbuilding, engineering planning, scheduling and control should be a part of an integrated management information system utilizing a common data base.

ENGINEERING PROJECT PERFORMANCE REPORT

GROUP REPORT

PROJECT NO 123 GROUP NO 410 REPORT DATE JUNE 7,1976 PAGE 7

DWG OR ITEM NO	DESCRIPTION	CHG NO	COMP DATE	EST HOURS	PCT COMP	ALLOWED HOURS	ACTUAL HOURS	VAR HOURS	VAR PCT	PROJD HOURS	SCHD DAYS	DAYS REMN	DAYS REQD	DAYS LATE	REQD O/T HRS/DAY
1-3302	CARGO TANK	111	22MAR76	160	100	160	146	14	8.8	146	20	0	0	0	0
	HATCH COVERS	112	29MAR76	24	100	24	28	- 4	-16.7	28	3	0	0	0	0
	ARRG & DETAILS	113	12APR76	24	100	24	19	5	20.8	19	3	0	0	0	0
		116	26JUN76	16	0	0	0	0	0	0	2	2	0	0	0
1-3401	AIRPORT &	111	26APR76	240	100	240	264	-24	-10	266.7	30	0	0	0	0
	WINDOW LIST	112	3MAY76	40	100	40	32	8	20	32	5	0	0	0	0
		113	17MAY76	40	100	40	44	- 4	-10	44.4	5	0	0	0	0
		116	12JUL76	24	0	0	0	0			3	3	3	0	0
1-3601	HULL INSULATION	111	12MAY76	120	100	120	110	10	8.3	110.0	15	0	0	0	0
	ARRG & DETAILS	112	19MAY76	16	100	16	20	- 4	-25	21.3	2	0	0	0	0
		113	31MAY76	16	0	0	0	0			2	2	0	0	0
		116	29JUL76	12	0	0	0	0			1.5	1.5	1.5	0	0
1-3602	JOINER WORK	111	24MAY76	320	100	320	290	30	9.4	353.2	40	0	0	0	0
	STANDARD DETAIL	112	7JUN76	64	60	38.4	42	- 3.6	- 9.4	66.4	8	0	3.5	3.5	XXX
		113	21JUN76	64	0	0	0	0			8	8	8	0	0
		116	16AUG76	40	0	0	0	0			5	5	5	0	0
2-3602	JOINER WORK	111	31MAY76	120	100	120	110	10			15	0	0	0	0
	ARRANGEMENT	112	7JUN76	16	80	12.8	8	4.8	37.5	10.0	2	0	1	1	XXX
	MAIN DECK	113	14JUN76	16	0	0	0	0			2	2	2	0	0
		116	2AUG76	12	0	0	0	0			1.5	1.5	1.5	0	0
3-3602	JOINER WORK	111	14JUN76	160	80	128	150	-22	-17.2	193.2	20	5	5.4	0.4	.64
	ARRANGEMENT	112	21JUN76	24	0	0	0	0			3	3	3	0	0
	01 DECK	113	28JUN76	24	0	0	0	0			3	3	3	0	0
		116	5JUL76	16	0	0	0	0			2	2	2	0	0
4-3602	JOINER WORK	111	5JUL76	400	60	240	255	-15	- 6.3	426.9	50	20	21.5	1.5	.6
	ARRANGEMENT	112	19JUL76	80	0	0	0	0			10	10	10	0	0
	02 DECK	113	2AUG76	80	0	0	0	0			10	10	10	0	0
		116	9AUG76	40	0	0	0	0			5	5	5	0	0
5-3602	JOINER WORK	111	12JUL76	320	30	96	88	8	8.3	293.4	40	25	25.7	0.7	.23
	ARRANGEMENT	112	26JUL76	64	0	0	0	0			8	8	8	0	0
	03 DECK	113	9AUG76	64	0	0	0	0			8	8	8	0	0
		116	16AUG76	40	0	0	0	0			5	5	5	0	0

FIGURE 32

ENGINEERING PROJECT PERFORMANCE REPORT

SUMMARY REPORT

PROJECT NO 123 REPORT DATE JUNE 7,1976 PAGE 1

CHG NO	DESCRIPTION	EST HOURS	SCH PCT COMP	ACT PCT COMP	ALLOWED HOURS	ACTUAL HOURS	VAR HOURS	VAR PCT	PROJD HOURS	SCHD DAYS	DAYS REMN	REQD MEN/DAY
111	DRAFTING	9016	52.3	50.3	4517	4727	- 210	- 4.7	9460	200	80	7.4
112	BILL OF MATERIAL	2350	46.1	45.3	1065	1040	25	2.4	2294	200	90	1.7
113	DWG CHECKING	1840	37.5	39.7	730	710	20	2.7	1790	200	105	1.3
116	APPROVAL CHANGES TO DWG	2240	21.3	22.3	500	470	30	6.0	2106	200	145	1.4
117	ENGINEERING SUPERVISION	3800	33.3	35	1330	1345	- 15	- 1.1	3842	400	190	1.6
119	ENG SERVICES TO YARD	1500	7.4	5	75	100	- 25	-33.3	2249	400	385	0.7
121	PURCHASE SPECIFICATION	400	100.0	100	400	393	7	1.8	393	20	0	0
122	MATERIAL ORDERING	600	100.0	81	486	470	16	3.3	580	25	0	XXX
123	VENDOR TECH ANALYSIS	400	95.3	97	388	395	- 7	- 1.8	407	150	75	0
125	VENDOR DWG APPROVAL	600	76.6	72	432	380	52	12.0	528	150	140	0.1
126	ALLOWANCE LIST	1000	0	0	0	0	0		1000	40	365	0.3
131	BOOKS AND MANUALS	450	25.3	30.	135	138	- 3	- 2.2	460	150	365	0.1
132	DWG REPRODUCTION	800	44.2	45	360	351	9	2.5	780	200	365	0.2
134	SCHEDULES AND PROG REP	240	36.6	35	84	80	4	4.8	228	300	385	0
135	CONFERENCES	400	36.6	35	140	146	- 6	- 4.3	417	300	385	0.1
136	TEST AND TRIAL AGENDS	200	0	0	0	0	0		200	20	20	1.3
141	TAPE CONTROL	1200	57.6	59	708	699	9	1.3	1184	75	50	1.2
142	MATERTIAL REQUISITION	200	50.1	52	104	100	4	3.9	192	20	60	0.2
143	PROCESS SHEETS	400	50.1	52	208	198	10	4.8	381	30	60	0.4
	CONTRACT TOTAL	27636	42.9	42.2	11662	11742		- 3.1	28491			18.0

FIGURE 33

8.0 REFERENCES.

(1) "Outfit Planning", The National Shipbuilding Research Program (NSRP), MarAd 1979.

(2) "Product Work Breakdown Structure", The National Shipbuilding Research Program (NSRP), MarAd 1982 .

(3) "Design for Zone Outfitting", The National Shipbuilding Research Program (NRSP), MarAd 1983.

(4) "Manufacturing Technology for Shipbuilding", Avondale Shipbuilding Technology Transfer Symposium sponsored by MarAd, 1982 .

(5) T. J. Peters and R. H. Waterman, "In Search of Excellence", Harper & Row.

(6) J. Naisbitt, "Megatrends", Warner Books .

(7) T. Lamb, "The Impact of N/C on Shipyard Management", SNAME Hampton Road Section, 1974.

(8) "Improved Design Process", The National Shipbuilding Research Program (NSRP), MarAd 1977 .

(9) T. Lamb, "Engineering for Modern Shipyards", SNAME GL or GR Section, 1978 .

(10) "Integrated Hull Construction, Outfitting and Painting, (IHOP)", The National Shipbuilding Research Program (NSRP), MarAd 1983 .

(11) T. G. Hicks, "Successful Engineering Management", McGraw-Hill Book Co.

(12) W. A. Cohen, "Principles of Technical Management", AMA.

(13) V. G. Hajek, "Management of Engineering ProjectS", McGraw-Hill Book Co.

(14) T. Lamb, "Engineering for Ship Production", The National Shipbuilding Research Program (NSRP), due to be published early 1985.

(15) B. Baxter, "Qualifications for Shipbuilding", RINA Transaction, 1971.

(16) L. D. Chirillo & R. D. Chirillo, "Flexible Manufacturing - What it Means in Shipbuilding", SNAME PNW Section, February 1984 .

8.0 REFERENCES - (Continued)

(17) D. B. Lunch, "Education of Technician Engineers & Technicians for the Shipbuilding and Ship Repair Industries," RINA Symposium on Education and Training for Naval Architects and Ocean Engineers, April 1976.

(18) J. B. Caldwell, "The Chapman Report - Ten Years After."

(19) Dr. B. Baxter, "Training and Development for Shipbuilding", IESS, Vol. 125, 1981-82.

(20) "Recommendations for the Training of Technician Engineers and Technicians, Training Policy Statement No. 16, British Shipbuilding Industry Training Board.

(21) "Symposium on Education and Training for Naval Architects and Ocean Engineers", RINA, April 1976.

9.0 ACKNOWLEDGEMENTS

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Comment by L.D. Chirillo on
"Engineering Management for Zone Construction"
presented by T. Lamb to the
11-13 September 1985 NSRP Annual Symposium

Any historian who writes in the future about shipbuilding would have to recognize the decade of the 1980s as one in which U.S. shipbuilding methods were revolutionized. What has, is and will continue to take place is a shift from system-oriented to zone-oriented logic. Thus, any paper which draws attention to problems associated with the transition is performing a useful service.

As the author suggests, before consideration of engineering management for zone construction, there must first be knowledge of how information can best be organized to incorporate a production department's build strategy. Thus, it is better to regard basic design as consisting of concept, preliminary and contract design only, and, most important, in fact vital, to regard contract design as part of the shipbuilding process. There is now precedent in the U.S. shipbuilding industry.

Exxon/Avondale for recently completed product carriers and Exxon/NASSCO for current tanker construction, worked together to produce mutually satisfactory contract designs which address both the owner's requirements and the shipbuilders' build strategies. With more development of statistical accuracy control methods, future such negotiations of technical matters before contract award will include the accuracy (quality) level that a ship will be built to.*

Of equal importance is the need to distinguish zone outfitting from pre-outfitting. "Zone" is a convenient contraction. What is really meant is "zone per stage", in other words, an outfitting opportunity ideal for a work package. Such opportunities can be recognized in a preliminary design, e.g., outfitting the forward half of an engine-room flat at first when it is upside down and latter when it is righted comprise two work packages that are envisioned before contract design starts. The description of such opportunities by production engineers is a build strategy which at first guides the development of contract design.

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* This should be of keen interest to the U.S. Navy. Apprehensive about as-built accuracy, the Navy recently aurhorized photogrammetric surveys of entire hulls. In the commercial world, letters of intent are usually the basis for negotiating technical matters before contract award. The same approach does not seem possible for naval ships until there is realization that about 73% of naval shipbuilding funds is applied in only three shipyards mostly on a negotiated basis, e.g., for Nimitz-class aircraft carriers, Trident submarines and some lead ships of other types.

As contract, functional and transition design developments each make more information available, production engineers are able to refine their build strategy in time to guide succeeding design phases. Literally, the design output is work instructions per work package. There is no post design effort required wherein planners obtain bits of information from many system drawings in order to compose a work package for outfitting a block, for example, as in preoutfitting. In the absence of such sophisticated guidance from a production department starting with production engineering input to contract design, a design department will continue to work in isolation regardless of its organization.

The author's Table I is excellent. It can be summarized by saying that the zone approach features detail design, material planning and material procurement each progressing in the same sequence that work packages are organized for production, i.e, all departments perform per truly integrated schedules in accordance with a common strategy. Regretfully, the author's paper contains **a** gross error. Figure 19 does not reflect the organization described in **a** series of "MarAd/SNAME sponsored IHI" publications. The author's Figure 22, which describes an integrated hull construction, outfitting and painting organization, should be substituted. However, regardless of the author's notations, the organization shown in Figure 22 is entirely product oriented except for electrical, which remains functionally organized due to tradition **as** reported in one of the MarAd/SNAME/IHI publications. Also, product and process are synonymous in the context of Group Technology (GT) and process flows exist for outfitting and painting in addition to those for hull construction.

At the peak of shipbuilding activity in Japan, about 1974, IHI's organization consisted of three departments, hull construction, outfitting and painting, each of which addressed an inherently different type of work. This logic was extended within each department; a clean separation was maintained between fabrication and assembly work. For example, hull construction shops separately addressed part fabrication, sub-block assembly, block assembly and hull erection. As a consequence of such management specialization by products classified per GT logic, production line benefits were achieved to. a degree not achieved elsewhere for building ships.

Regarding fabrication of fittings, only a shop for manufacturing pipe pieces existed as virtually all other fittings, including foundations, were obtained from subcontractors. The objective was to concentrate management attention only where sufficient work flows could be obtained in accordance with GT, i.e., the production of pipe pieces.

Three outfit assembly shops were product organized by specialties, i.e., accomodation, machinery and deck (deck is other than accomodation and machinery), and, the fourth, electrical, was retained as a functional organication. Usually, the order is given as deck, accomodation, machinery and electrical, as shown in Figure 22, and the acronym DAME is used.

There is something to be learned from the affect of the continuing shipbuilding recession. Figure 5-3 of the MarAd/SNAME/IHI publication "product Work Breakdown Structure (PWBS) - Revised December 1982", shows the IHI organization as of about 1974. Since then, painting was changed from a two-shop department **to a** single shop assigned to the Outfitting Department. The next change combined sub-block assembly and block assembly under a single shop manager. The latest change combines hull construction and outfitting under a single department manager. Thus, as the work force gets smaller, there is a **tendency** toward **a** traditional functional organization.

However, such changes impact at department and shop levels only. For budgeting and costing purposes, work flows by problem categories at supervisory levels within shops remain separated so as to exactly match the PWBS employed. In this respect, Figure 5-3 is still valid. Its strength is in the exact matching of how work is organized within shops to the PWBS. The author's mixing of inherently different types of work in his suggested organization could not have the same powerful advantage.

While product organizations are preferred for all large manufacturing firms having high rates of technological change and need to be flexible in marketplaces, they cannot be applied dogmatically in search of "pure" organization form as the author proposes. After all, even with electrical as an exception, IHI's degree of electrical components, particularly electric cable, fitted on block is equivalent to or exceeds that achieved elsewhere. That which is produced, is definitely in conformance with product orientation. An overriding need is not for a pure organization of one form, instead, it is for the detail design, material marshalling and production efforts to be organized in the same way so as to enhance communications between them. Another overriding need is to get production people to develop a build strategy before contract design starts.

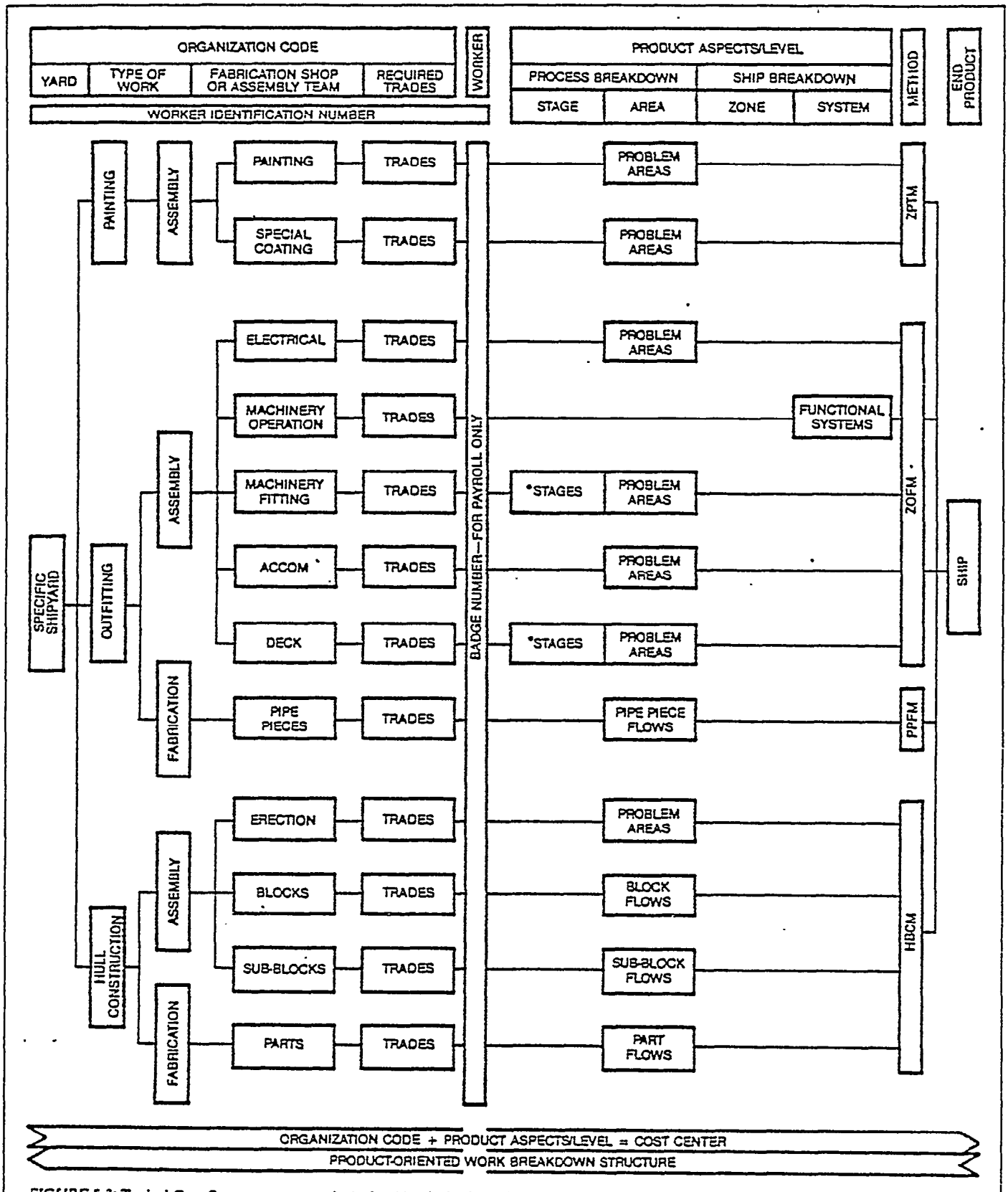


FIGURE 5-3: Typical Cost Centers are separately depicted by the horizontal combinations on each line. Cost centers shown *exactly match* the shipyard organization. With few exceptions, the yardsticks used for performance measurement are based upon work packages grouped by problem area per level. Yardsticks are whatever best suits circumstances at each manufacturing level. *Control by stage is added only when there are special or extensive welding requirements. Otherwise, welding incident to normal fitting is performed by fitters; control by problem area is sufficient.

DISCUSSION on T. Lamb's Paper "Engineering Management for Zone Construction of Ships"

I wish to compliment Mr. T. Lamb on his paper, which provides a valuable overview of various Engineering Management principles and its applicability to zone construction.

A question arises in regard to the reduced Engineering lead the required if zone construction is applied. I have read articles to the contrary. In general, the preparation of zone type drawings will still require complete development of many scantlings, piping, electrical systems and arrangements to make the zone construction drawing as intended, and. unless the Shipyard or Design Agent has a considerable Engineering staff (rather unlikely in today's 'market), this will require time.

The idea is to spend a bit core time "up front" and reduce the production. ***tine.***

Another area requiring some clarification is the ***term "zone"*** as used in the paper versus the use of this word by SNAME/IHI/IMOP.

we do agree with the concept of "Product Engineering" and the idea of incorporating the Planning function in this group, but the breakdown in Hull, Deckhouse and Machinery Space appears to apply only to commercial vessels, and, as Figure 26 illustrates, requires duplication of effort by the three (3) groups. For example, structural work is being done by two groups but in the Production area, will require the same skills, tools, facilities and materials. Thus, a single source for data provisioning would be more beneficial.

The Engineering staffing in shipbuilding is indeed a problem. However, considering the present shipbuilding market, this problem may be solved in the near future.

We anticipate that real shipbuilders will stay with us, but also be willing to accept the new concepts within the Industry, such ***as*** T. Lamb's paper outlines.

Discussion comments re:

20 August 1985

ENGINEERING MANAGEMENT

FOR

ZONE CONSTRUCTION OF SHIPS .

What Mr. Lamb is proposing in this paper has merit in that the elephant is eaten in smaller bites and more bites at the same time. This approach, if properly supported, will work. I think it would be wise to look at a 'few of these support requirements because without them, this approach to engineering/ design management will surely fail.

1. Early and Complete Staffing.

The traditional design spiral still remains as an integral requirement of the three basic breakdowns that are proposed in this paper ... HULL - MACHINERY SPACE - DECK ROUSE. The same functional requirements and trade-offs must be iterated. The difference in Mr. Lamb's approach is that it will require staffing of the three basic zones concurrently and early in all the functional areas. This will raise the number of functional engineers required over the traditional approach where the design spiral is iterated over the entire ship.

2. Interface Management.

The proof of the pudding in this design management approach is the interface of the three zones. None of the three areas can live as an entity to themselves. The problems associated with interface between the zones are myriad and are not addressed in this paper. Proper attention to this particular area is vital if the marriage of the zones is to be successful. There are many systems which of necessity must be-designed as a complete

system which cross the zone boundaries (HVAC, firemain, control and alarm, etc.). This effort must be identified and supported as input to the zones for the zone effort to succeed.

3. Management of Design "Schedule Busters":

The success or failure of this approach, as Mr. Lamb points out, is maintaining the design schedule. This will require Herculean effort on the part of design and purchasing personnel to obtain the required vendo'r information and also requires starting with complete technical specifications with the absolute, minimum of customer interference resulting from change orders. Figure 7 shows this dramatically where the engineering and material definition are shown concurrent for the first four months after contract award. The slope of these two curves is almost vertical in the fifth month. I submit that performance of this sort is impossible given the current competitive economic conditions in this country. It will be neigh on to impossible to select vendors, place purchase orders, and obtain the requisite design/vendor information in this time frame. I submit that this is the single greatest shortfall in this approach to engineering management for zone construction of ships.

Figure 7 also dramatically shows why the customer must maintain a "hands off" position in regards to changing the product after contract award. There is no time allowed in the design process to reverse or hold up any work once started. This is particularly germane in military construction where government change orders are a way of life.

4. Naval Contracts vs. Zone Construction:

It is no secret that for the foreseeable future in the United States that the U.S. Navy is about the only customer around. Unfortunately, this will place a huge roadblock in any serious effort to reduce the design and construction time of ships. The Naval Sea System Command and its associated contract requirements prohibit this improved performance. Vendor procurement requirements alone will throw the schedule way off. Poor contract specifications and a penchant for always updating specification requirements will ***throw*** enough "schedule busters" to choke the elephant we are trying to eat faster. The NAVSEA tech codes are still mired down in their systems approach to new construction. Where technical approval is required, you can forget about shortening any time cycle. NAVSEA and their attendant bureaucracy can-not react to zone construction design approach.

Another point to consider is that U.S. Naval Construction, particularly warships and amphibians, will require' more zones than the traditional hull-machinery space-deck house approach. Therefore, the staffing is that much more difficult and the interfaces grow accordingly.

I appreciate Mr. Lamb's approach and feel that it is aiming in the right direction. I question if it is doable-do with our current shipbuilding contract practices . . . particularly, naval contracts.

Respectfully submitted:

Frank H. McGrath
. Chief Engineer
. PETERSON BUILDERS, INC.

AUTHORS REPLY

I agree with Mr. Chirillo that it is vital for Contract Design to be part of the shipbuilding process and always suggest that it be developed along with the shipyard Building Plan (Build Strategy) for the design. There is no doubt in my mind that the cases he listed provided both the shipowner and the shipbuilder the best possible design to be constructed in the shipyard and operated by th owner. However, I dissagree that Functional Design should be excluded from Basic Design. I recognize that my approach is hot what IHI suggests, but as I see it Functional Design uses all the knowledge, skills and calculations that are used in eaflieridesign. It expands the incomplete Contract Design into a Total Design for the ship. Once Functional Design is completed, there should be no need for real "design" actions. Transitional Design, which could be called Transitional Detailing, involves the integration of the completed systems design into interference free, producible arrangements. Work Station/Zone Information preparation involves transmitting the data necessary for the production workers to fabricate and install the. components. Therefore, for my convenience as an engineering manager, I feel it is more logical and thus prefer to keep all design together under Basic Design.

I admit that Figure 19 does not look like the usual repres-encation of the IHI engineering organization but question whether it it is a gross error". my intent was to show the differences between Japanese, American and British approaches in three figures on the same page and thus tried to use a common nomeclature. I have prepared a revised but still modified organization for the IHI engineering to show my intention better in Figure 36.

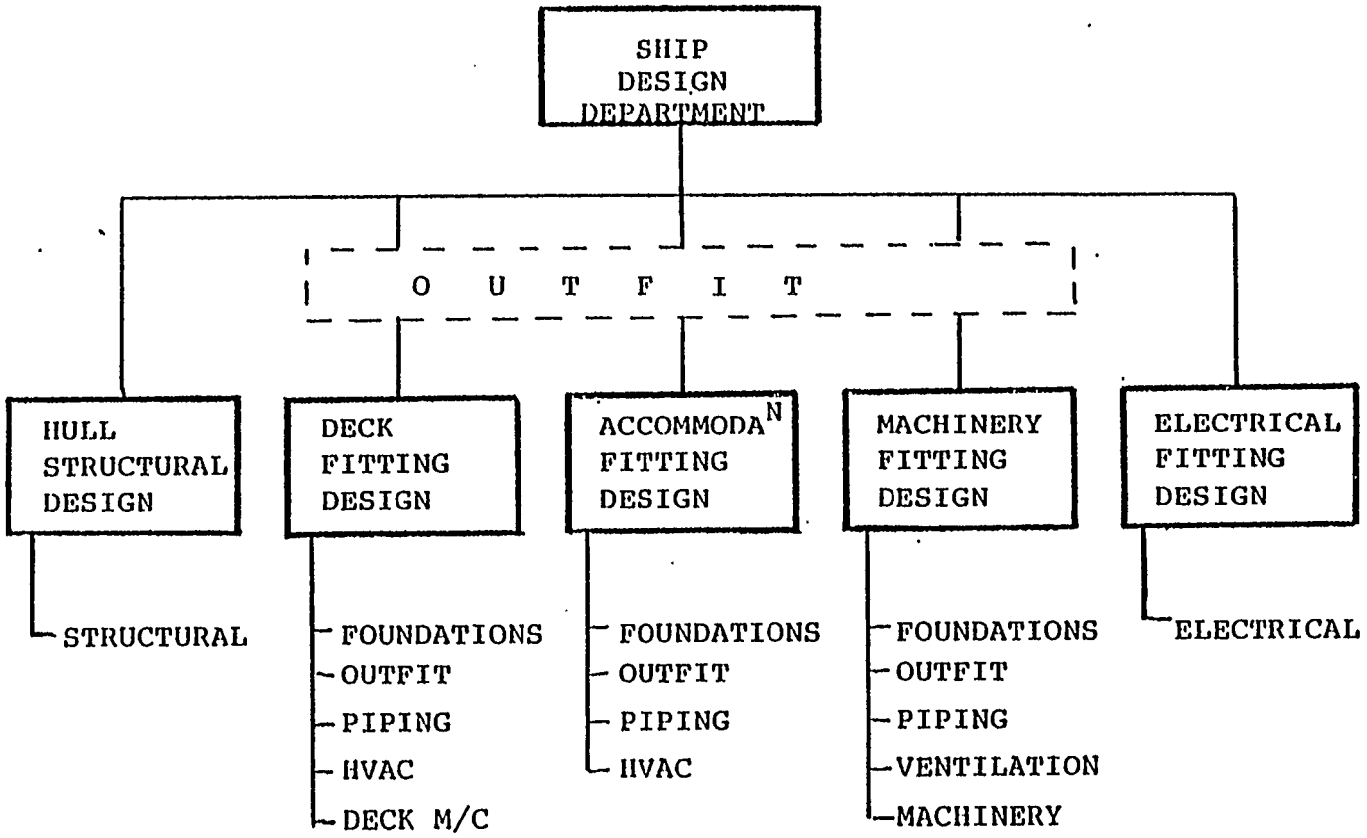


FIGURE 34 MARAD/SNAME/IHI ENGINEERING ORGANIZATION

I also dissagree that Product and Process are synonymous in the context of Group Technology. Mitranov, the father of Group Technology, clearly showed that Process Methods were in existance before and are a separate approach to Group Technology. However, the GT Method may utilize Process Methods within its production cells.

Mr Chirillo's update on the changes at IHI- confirms that most ideas can be improved uponly especially when circumstances' change. I used the word "pure" to describe what the IHI organization is not and as a consequence that as it is based on THEIR unique circumstances should not be copied but be adapted to suit another's, We should adopt their good ideas but leave those based on their traditional problems alone. We have plenty of our own traditions co deal with!

It is ***not*** and never has been my intent to detract from the valuable and important part played by the IHI Technology Transfer, but rather I am suggesting that the Japanese ideas can be adapted with/additional benefit for different shipyards and their circumstances in the same way the Japanese improved upon American and European shipbuilding ideas in the early 1960's.

I have been a life long believer and practitioner of the quotation by H. G. 'Wells, "chat one man's idea can always be improved in the minds of others".

In reply to Mr. Posthumus, I am not suggesting that Engineering for Zone Construction allows reduced lead time but rather that Zone Construction along with shorter build cycles requires it.

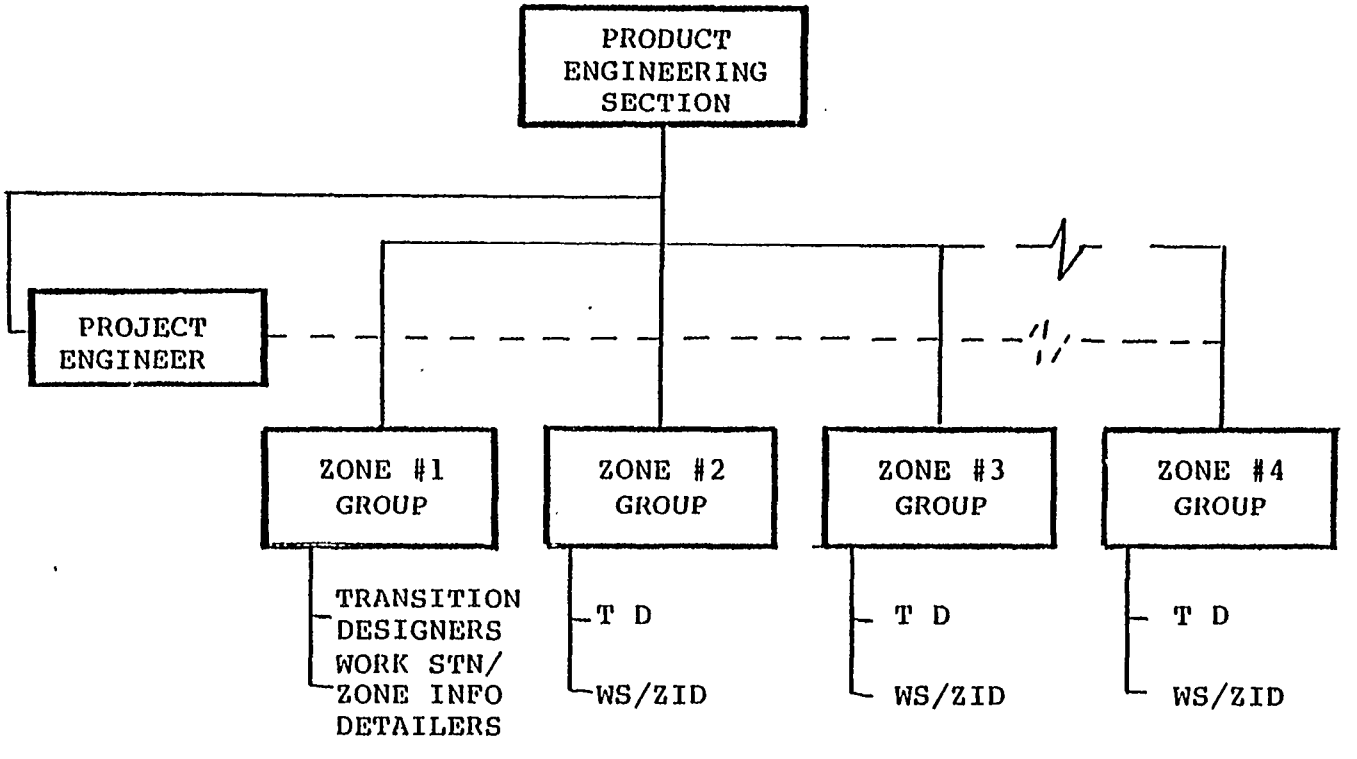


FIGURE 36 - PROPOSED PRODUCT ENGINEERING ORGANIZATION FOR WARSHIPS

of the zone groups are of only two designations, namely. Transition Designers and Work Station/Zone Detailers. This is another change (to the better, I believe) that I have mad2 based on my experience at TBC. As all design calculations and system diagrammatics are prepared during Basic Design (Functional), there is no need for knowledge of the different traditional disciplines in either Transitional or Work Station/Zone Information preparation but rather an overall integration and work practice knowledge instead.

It was amusing to me to see that Mr. McGrath has also been asked, "How do you eat an Elephant?" and knows that the answer is "in many small pieces". I never associated my approach with that technique and I thank him for doing so.

With regard to his specific comments, first, I dont see the traditional design spiral applying after the completion of Functional Design. Thus it would not impact the zone grouping in Product Engineering. The completion of design and the greater detail in preparing system routing diagrammatics during Functional Design MAY require more "Functional Engineers" but there will not be any increase due to any extension of the design spiral into Product Engineering.

Secondly, the logical completion and organization of the design during Functional Design provides the basis for an effective interface information and control. I agree that attention to this aspect is of extreme importance to the success of the approach.

Fortunately, by departing from the traditional structure first then machinery then electrical cascading preparation of engineering to complete engineering by zone, the task is reduced in scope. Instead of the traditional structure, piping, electrical and HVAC system arrangement drawings, structural module drawings and accurate dimensioned routing diagrammatics are prepared before commencing Product Engineering. This is fully discussed in the SNAME SP-9 Panel publication "ENGINEERING FOR SHIP PRODUCTION", to be published this Fall.

Mr. Posthumus is correct, I do use a different zone approach to the Zone/Area/Stage approach of the Japanese. My approach is based on my experience from shipyards that were using the zone approach in 1962. I have continued to expand the concept and its use to a hierarchical method similar to the one described in the paper. I use zones to define any desired portion of the ship in which work is to be performed in erected structural modules. Prior to that work is designated by work station and the engineering information is prepared for each work station.

The division of major zones into Hull, Deckhouse and Machinery Spaces is applicable to certain non-commercial ships, such as large warships where the deckhouse is a logical independent part. Also, I believe that the type of structural work being performed for Hull versus Deckhouse is sufficiently different to warrant its separation. However, I agree that for small combatants such as frigates or corvettes it is not the best approach, as I have found out since joining Tacoma Boatbuilding Company. For a number of reasons, the division shown in Figure 35 is better. The engineering organization shown in Figure 36 would then result. It should be noted that the staff in each

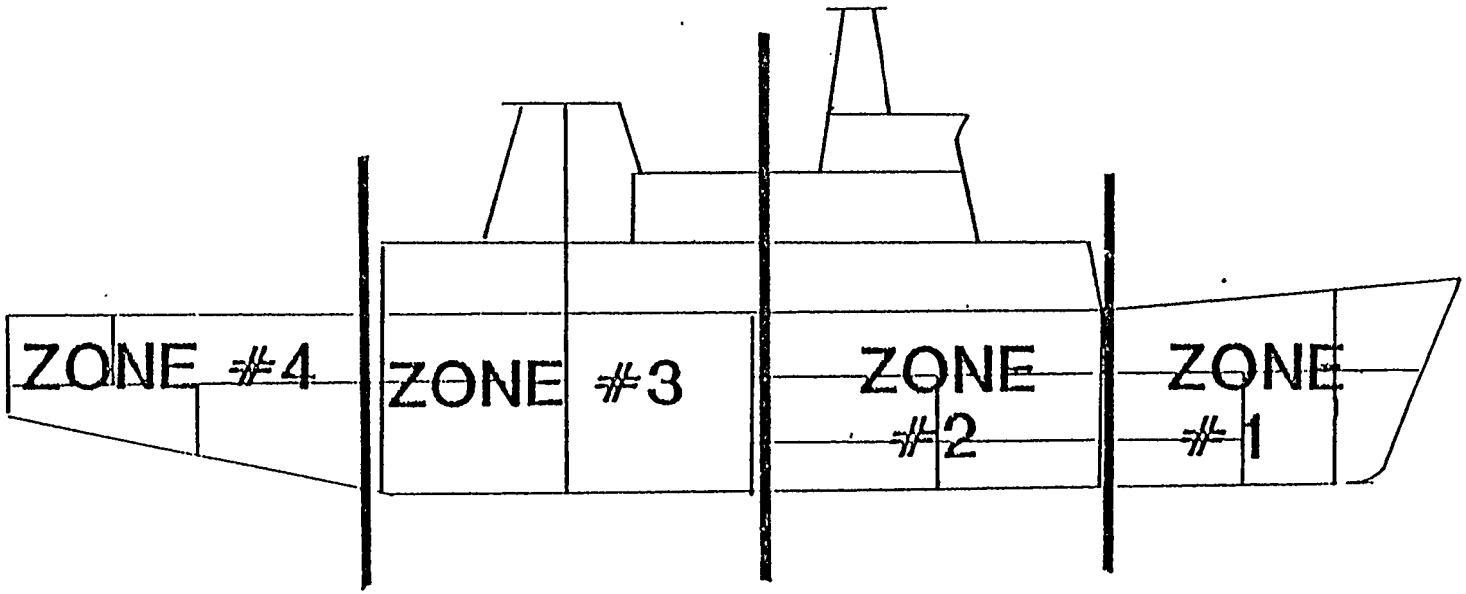


FIGURE 35 - ZONE DEFINITION FOR WARSHIPS

COMMENT by R.H. Slaughter, Jr. Ingalis Shipbuilding Division, Litton -

1. Education Aspects - Professionals

while much has been written about the benefits of zone construction methodology for shipbuilding as regards the construction process per se, only a few writers have addressed the necessity for radical changes in training of engineers to support the operations force. This paper begins to address this *issue*.

Paragraph b addresses the matter of training and provides some good references.

Paraphrasing the Biblical passage, "and a little child shall lead them", our "little children" are the undergraduate students in naval architecture marine, and ocean engineerng *courses in* various academic institutions. These students will learn something of the process of shipbuilding one way or another, and will only apportion a certain (small) amount of time to it. The following suggests a means of accomplishment that will attract student attention while not being burdensome to imliment

I submit that we take the simplest steps first and proceed about as follows:

a. Adopt as text material the National Shipbuilding Research Program (NSRP) monographs on the ,"new" method of shipbuilding. This work, done under the auspices of the ship production Committee (SPC) of the Society of Naval Architects and Marine Engineer (SNAME) is definite and concise. It has been we11 Americanized and males good source material

Academit instutitions will accept volunteer lecturers who have become "born again" shipbuilders to present lectures to students, on the basis that the way to build ships is the "new way Do not waste time discussing older convertional methods.

C. Utilize the SP-9 Panel (Training and Education) lesson plays and audio visual aids under development for these lecturers' use. This will standardize the presented material.

d. Cause the NSRP lectures to be "for credit", examining students on the material.

e. Establish programs, using the Sp-9 panel material, both to local Junior Colleges serving the industry, and to training organizations of shipyards and allied activities.

In following the above, we can rest assured that in a very few years, the new generation of entry-level engineers and technicians will infiltrate the industry and will *cause* the oldsters to see the light.

It will be amazing to see how quickly the older hands will pick up *new* ideas, even if from youngsters!

2. Measurement of cost Effectiveness, or If You Can't Measure It, *You* Can't Manage It

During the past secale and a half, the benefits to be derived by adopting the new technology have been propounded almost exponentially. Each shipyard that has changed methods

of Construction from conventicral to zone philOSophy has anncunced how great it is. Shipyard visits reveal units being erected and pre-outfitted to a markedly advanced degree. There is little fear That the pieces will not fit.

Lacking is measurement of the claimed cost effectiveness that will enable managers to evaluate in terms of dollars or percentages of manhour expencitures the expected return on investment. Such a discussion is coubtlessly beyond the scope of this paper, but the cost of engineering is a significant one in the cost of a ship, and the organization of the engineering departments has a. great bearino on that cost.

An analysis of Costs for various organizational structures described in the paper would be most interesting. It is suggested that discussion of engineering projectization by zone, exactly counterparting the planning and opercticns functions on a percentage of cost basis, would be most valuable.

The another has chronicled a very current and dynamic subject. He has brought into the open the involvement of engineerin in the methodology of zone construction. It is hoped that this work will be the impetus for him to pursue other aspects of shipbuilding bearing on zone technology, including financial aspects of adopting the new technology

The opinions expressed herein are those of the author and do not necessarily reflect policy or opinions of the Ingalls Shipbuilding Divisicn of Litton.

Thirdly, the goal considered in the paper is to organize engineering to help U.S. shipbuilders become more competitive with shorter build schedules. I suggest that the current shipbuilding conditions in this country and the NAVSEA contracting practices make the proposed schedule performance unnecessary rather than impossible. However, all that this does is spread the schedule over a longer duration. The sequencing and the relative phasing remain the same.

Fourthly, I agree that Naval Contracts can deter innovative approaches to both design and construction. However, it should be appreciated that as the Functional Design PTS's, drawings, parts lists and schedules are complete, they are suitable for all approval actions.. No Product Engineering document is submitted for approval.

Finally, I dissagree that the approach is un-doable in today's conditions. Such an approach as described is not only doable it is necessary for U.S. shipyards that want to survive and are searching for significant productivity improvement from design through construction to successful delivery.

I appreciate Mr. Slaughter's suggestions on how to introduce new students to the "new" shipbuilding techniques and hope that they will be adopted. Both the University of Michigan and the University of Washington offer Ship Production Technology courses to their students. However, I see the bigger training problem for existing shipbuilders and that is why I persevered in my persuasion to have further education courses on Ship Production Technology at the University of Washington. The course has been held four times over the past three years.

The question of the "cost" of engineering for zone construction has been addressed in a general way by a number of sources, the best known being the Avondale IHI Technology Transfer report. The additional cost in manhours has been quoted from double to three times traditional engineering. This is not my findings. I have accomplished my proposed approach for a 30% increase for commercial ships and this increase was totally offset by elimination of planning effort. For a small naval combatant vessel, the increase was nearer 65% due to the special drawings (CDRL items) that the Navy still demands.

PRODUCIBILITY AS A DESIGN FACTOR IN NAVAL SHIPS

by

LCDR MICHAEL L. BOSWORTH, USN

CAPT CLARK GRAHAM, USN

ABSTRACT

There are many producibility concepts which affect the characteristics of a naval ship. These concepts must be addressed during the early phases of the ship design process while the ship is still flexible. Since these producibility concepts may affect ship performance and technical risk, as well as ship characteristics and cost, a rigorous tradeoff analysis is required.

This paper provides examples of producibility concepts which should be addressed during the ship design process. An evaluation procedure is presented to assist in the gathering and the organizing of information required for an objective tradeoff analysis. The ship synthesis model "ASSET" is utilized as the principal design tool to determine ship impact and the cost of producibility concepts. One of the primary recommendations of the authors is that the Navy needs to increase the visibility of producibility as a design factor in naval ships by developing rigorous evaluation tools, cataloguing producibility concepts for considerations in future designs, and establish an advocate for ship producibility within the design organization.

INTRODUCTION

Most of the material written on the subject of ship producibility focuses on enhancing efficiency and producibility during the ship building process after the basic ship design has been completed. Ship producibility is in fact not a serious consideration during the early design phases of a *naval* ship. Questions arise such as: Why is producibility not a serious factor in the early stages of the design of naval ships? Can ship producibility be enhanced by designing it into a naval ship from the outset? If the answer is "yes" (which the Authors have concluded is true), how can producibility considerations best be incorporated into the naval ship design process7 These are the fundamental issues to be addressed in this paper.

The Authors have approached this subject on a broad conceptual 'level. The basic research was conducted at M.I.T. by Ledr Bosworth as a graduate thesis with Captain Graham serving as his Advisor. The intention was to develop source material on the subject of ship producibility for incorporation into the MIT graduate curriculum. The objective of this effort was to provide a framework for future studies in this area.

This Paper will summarize the more thorough report (Reference 1) and will cover the following topics:

-Unique Features of a Naval Ship
- Producibility as a Design Factor
- Producibility Conceptual Framework
- Wartime Producibility
- Peacetime Producibility Categories

- Conclusions and Recommendations

UNIQUE FEATURES OF A NAVAL SHIP

Naval combatant ships (submarines, aircraft carriers, frigates, destroyers, cruisers) are among the most complex products man designs and produces. There is no other system that must perform so many diverse and highly sophisticated functions simultaneously. The diversification of functions in naval combatants is caused by the requirement to be effective in all four welfare areas (subsurface, air, surface, and strike); be mobile; operate efficiently in an extremely hostile natural environment; survive weapon effects; and sustains itself for long periods of time and over great distances away from a logistic base. To a designer this means that there are numerous major design elements to address throughout the design process.

It has been estimated that a naval combatant ship consists of approximately 100 major components and subsystems. Some of the major components include: radar, sonar, weapon launcher, computer complex, communications complex, propulsion prime mover, electrical generator, machinery control system, and hull structure. Each of these in isolation represents a very sophisticated system often incorporating advanced technology. Most of these components have been developed prior to the integration process of ship design. However, in some of the more ambitious ship design programs, a number of key components are developed concurrently with the development of the ship design.

The size as well as the shape of naval ships must be

constrained for practical reasons of mobility and affordability. For this reason the physical integration of combatant ships represents a major challenge to package the widely diverse functions into a compact system design. The temporal integration of naval ships is even more important. All functions of a naval ship are expected to work simultaneously with extremely fast reaction times.

The necessity for physical and temporal integration of such a large number of widely diverse and complex functions represents the ultimate design challenge. Because each of the functions is so highly interactive with the others, the ship design process is an iterative vice serial set of tasks. Early iterations define the broad concept, middle interations focus on the engineering of component and subsystem interfaces and the later iterations on the development of the engineering details required for production. Figure 1 illustrates the iterative nature of ship design by means of a design spiral. The spokes of the wheel represents the design elements which must be integrated into the design. The loops of the spiral suggest a major iteration of the design process leading to a balanced baseline. All engineering design is an iterative process. What makes the design process of naval ships unique is the number of diverse functions and the degree of tightness in integration.

There are other important differences in naval ships as opposed to other complex engineering systems which have relevance to this discussion of engineering design and efficiency in production. Naval ships have relatively high unit cost (in the

vicinity of 1 billion dollars) and are rarely produced in numbers greater than 30. Thus there is not the opportunity to exploit the efficiencies of mass production. The Navy can rarely afford to experiment with a prototype. The first production ship becomes an operational unit in the fleet and therefore must be engineered and produced correctly the first time. An additional difference relates to the requirement to maintain these ships at the cutting edge of state-of-the-art engineering for the lifetime of the class (up to 50 years). This demands that naval ships be flexible and have the capacity for future growth.

All of the above observations have relevance to a discussion of ship producibility as a design factor in naval ships. This will be brought out more thoroughly in later sections of this paper.

PRODUCIBILITY AS A DESIGN FACTOR

In recent naval ship acquisition programs, producibility has not been considered a major element in the ship design process for several reasons:

- There exist a myriad of other elements that ***are*** considered more critical. There is so much diversification in the functions to be addressed during the ship design process of a combatant ship that the subject of producibility gets buried. In addition, producibility is not critical to the demonstration that the design has the capability to meet the operational requirements for the ship ***nor -is*** producibility a factor affecting the technical feasibility

of the design. Thus producibility tends to get little attention, especially in the early stages of the design process.

- There has been a decided lack of visibility and external pressure to increase the producibility of the basic ship design. There is no "Advocate" insisting that producibility considerations be incorporated into the design. There is' no threat of cancellation of a ship program if producibility is not an integral part of the engineering development. For many other considerations such as reliability/maintainability, test and evaluation, and integrated logistics support there are strong Advocates. A ship design team can only respond to so many outside pressures.

- There is a perception that the design community does address producibility through weight minimization or cost constraints. Unfortunately producibility ideas are not aggressively pursued for the purpose of reducing production costs. And many producibility concepts tend to increase the size and weight of naval ships and therefore are turned down.

- There is a lack of awareness of the relative leverage in cost reduction and ship impact resulting from ship producibility concepts. Most early stage ship designers *are* unschooled in modern ship production procedures. There is little data on specific producibility concepts to

incorporate into early stage designs.

- There is a lack of a rigorous methodology for the assessment of producibility concepts. The trade-offs among ship effectiveness, cost, and risk are not understood.

Now this is not to say that major ship acquisition programs ignore producibility during the ship design process. In general, the strategy of recent ship acquisition programs is to get the potential shipbuilders involved in the design process at the earliest possible time. However, since the shipbuilders for both lead and follow ships are not usually selected until after the contract design phase is completed, there is a sensitive relationship among the candidate shipbuilders and the Navy that hinders open communications. All the shipbuilders must be treated equally to avoid possible claims for preferential treatment. And, of course, the shipbuilders are all vying for a favored position.' There is also misunderstanding between the Navy's inhouse conceptual ship designers and the shipbuilders' detail designers and planners. Neither have a lot of experience in the others area of expertise.

Although some attempt is being made in addressing ship producibility. in early stage designs, 'the effort is not overly effective. This paper will recommend ways to improve this situation.

PRODUCIBILITY CONCEPTUAL FRAMEWORK

There are two major classifications which are useful for

focusing attention on the subject of ship producibility: "wartime producibility" and "peacetime producibility". The former is primarily concerned with schedule and production rate and the latter with acquisition cost considerations. The two classifications will have many producibility concepts in common, but the methods for evaluating those concepts will be quite different.

There has been voluminous amount of material reported on both wartime and peacetine producibility. Understandably greater emphasis has been placed recently on peacetime producibility since that is the condition the Navy and the shipbuilding industry have been in for the past four decades. (Hopefully this will not change.) Except for a brief discussion on wartime producibility in the next section, this paper will focus on peacetime producibility.

WARTIME PRODUCIBILITY

In wartime, or in a pre-war mobilization effort, schedule is of the essence and the task of constructing a large number of ships in time to effect the outcome of the conflict takes overwhelming precedence. Considerable historical data concerning wartime producibility exists and this type of data dominated post World War II producibility research material (See References 2 and 3).

In the thesis by Bosworth, a brief history of wartime producibility has been provided. The Steps the United- States took to produce the incredibly large number of merchant ships,

escorts, and major combatant ships in such a brief period of time are reviewed. The Authors will assume interested readers will review this reference and pass on to the observations and recommendations concerning wartime producibility.

The primary lessons from history for wartime producibility are:

- There must be a recognized national need and a measurable goal. Tremendous resources must be mobilized and shortcuts through the bureaucratic morass must be realized. This requires a sense of great urgency.

- Series production must be maximized and design changes minimized or phased in gently. The goal is to maximize the number of operational' ships in a given period of time. The ships must be effective but sufficient numbers take priority especially for the lower mix ships (merchants, amphibious, logistic, escort ships). A good design needs to be finalized and then turned over to industry for long series production.

- The timing must be accurate. Ships must be ordered months or years before they are delivered in large numbers. This permits a build up of materials and preparation of industrial facilities. The changing tide of war makes production forecasts difficult. There cannot be a stop-and-go decision making process if efficient series production is to take place.

- Design simplification and flexibility must be emphasized. Alternative materials and equipment must-be allowed to prevent competition for critical quantities needed by other programs.

Simplicity in design permits production at second echelon facilities leaving more capable shipyards free to concentrate on the more complicated, high capability ships.

The United States Navy cannot predict the form of its next war, but America's dependence on the seas certainly suggest the possibility of a lengthy maritime conflict. Such a conflict would require a mix of a relatively small number of highly capable ships (nuclear submarines, nuclear aircraft carriers and cruisers, and surface combatant ships (cruisers and destroyers) and a large number of lower capability ships (cargo ships, escorts, logistic and amphibious support ships).

The "high mix" ships are absolutely required for our Navy which emphasizes power projection and sea control. These ships are by necessity large and highly sophisticated. In peacetime, it takes over 10 years to design and construct a lead ship of this type and an additional 10 years to build out the class. The key to the "low mix" ship is numbers. As was experienced during the World wars, very large numbers of these less capable ships are required to keep the sea lines of communication open.

The general conclusion of the Authors is for the United States Havy to continue the emphasis on designing and producing high and mid mix warships during peacetime. These ships would be the primary "come as you are" components of our Navy forces at the time of conflict. These ships could not be produced fast enough to have an impact. in other than an extended duration war. In parallel, the Navy should plan 'a -mobilization effort to produce large numbers of less sophisticated low mix ships.

The specific recommendations for a mobilization effort for large numbers of low mix ships include:

- Predesign to the detailed plan level of a number of austere, low mix, wartime designs. These designs would be maintained current ("evolved" as are the sophisticated designs) and would encompass the following features:

  - smaller/simpler for production at alternate shipbuilding sites (not otherwise usable for major naval combatant construction).

  - use of alternate subsystems (not necessarily optimum from. an effectiveness standpoint) such as propulsion plant or armament that do not compete with the limited supplies available for the exisiting pre-war sophisticated designs.

  - simple to operate for manning by hurriedly trained reservists.

  - future growth capability so that the designs could incorporate changing mission requirements. Thus designs would be rather roomy and have generous margins.

  - flexibility of design to accommodate alternate combat systems as -available or as desirable for various wartime missions.

  - lesser standards for habitability, environmental control, and other items to simplify and speed

construction.

- Validate the detailed designs by actual construction of a limited number of prototypes. This would also provide an opportunity to train mobilization production personnel and provide affordable ships for use in training, reserve duty, and testing programs.

- Identify potential production bottlenecks to allow development of mobilization production capabilities. For example, if propulsion reduction gears were a primary bottleneck, incentive3 through legislation could be provided for private development of such a capability or machinery to that purpose could be stockpiled.

- Develop an assessment model for wartime ship designs. This design/schedule synthesis model would integrate component lead times, supply, production site capability, and cost-benefit to permit examination of a wide variety of designs in early phases of design.

The two key recommendations relate to the design and production of the austere wartime ships. The detailed design plans need to be in hand prior to the crisis and validated by prototype construction. The list of austere wartime designs to be assembled might include:

* Escort Frigate (ASW)

  Escort Frigate (AAW)

* Escort Carrier

- Multi-purpose Cargo (general cargo, roll-on/roll-off, container)

  Oil Tanker

  Landing Craft

* Mine Warfare Craft

  Fast Patrol Boat (missile)

  Diesel Attack Submarine

(The asterisk [*] indicates higher priority)

These designs and the follow-on prototype construction will of course compete with the design and construction of the Navy's mainstream ships. The Authors feel that about 5% of the total budget might be a reasonably level of investment for this effort.

PEACETIME PRODUCIBILITY CATEGORIES

In peacetime, the fundamental thrust in ship producibility **is** reduction in acquisition cost. One can consider five broad categories Of peacetime producibility: Fleet Concept, Preliminary Ship Layout, Production Details, Shipyard as Factory, and Programmatic Strategy. Each of these will be briefly described below.

Fleet Concept

Producibility should--be an issue when considering the most cost effective composition of the fleet. The Authors have already described the concept that the Navy should concentrate on building the large, complex warships during peacetime in order to have them ready at the start of a conflict. Smaller, less

complex ships can be built in large numbers in a shorter period of time during the build-up period prior to a conflict.

Other fleet concepts include Admiral Zumwalt's high mix and low mix policy of mixing more sophisticated ships with less sophisticated ones in order to attain sufficient numbers. The lower mix ships would be severely constrained ships and would be relatively easy to build in large numbers. Another fleet concept **issue** centers on the trade-off between multi-mission and single mission ships. The single mission ships would be smaller, less complex and easier to produce. Other proposals for commercial standards on some naval ships, and the idea of having a changeable payload are other examples of Fleet Concepts. The concept of commercial standards would permit more efficient ship production, especially in shipyards primarily experienced in commercial shipbuilding. The idea -of the universal platform which could be outfitted with a wide variation of combat **suites is** another Fleet Concept. This concept has recently been thoroughly studied by the Navy.

All of the above fleet concepts effect the performance characteristics and therefore the military effectiveness of naval ships. These-decisions must therefore be made by the customer, the Naval Operator, in conjunction with those skilled at estimating the ship impact and cost implications of the tradeoffs. These decisions must be made before the start of a serious ship acquisition project.

Preliminary Ship Layout

Once a ship design team has been provided with performance

requirement3 and design constraints, it proceeds to develop the design following the iterative phases of the Navy's ship design process (feasibility studies, preliminary design, contract design and detailed design). Producibility options which impact general arrangements, subdivision, dimensions, shape, or subsystem selection belong in this Preliminary Ship Layout category. These option3 must be investigated while the ship design characteristics are still fluid (i.e. before the design is frozen). Therefore they must be addressed during feasibility studies and preliminary designs.

The dilemma is that during the early design phases, the size of the design team is limited while the requirement for conducting numerous fundamental coat vs. performance tradeoffs leading to a selection of subsystems and ship characteristics is overwhelmingly demanding. Thus the resources available to pursue producibility tradeoff options are limited. This is unfortunate as the leverage for affecting the cost of the design through incorporation of producibility ideas may be greatest during these early design phases. With recent advances in computer aided ship design, a wider variety of options can be investigated with fewer manpower assets.

Some example3 of producibility concepts which should be addressed early in the design process when ship characteristics are still fluid include the use of various material3 for structure, outfit and distributed systems (piping, cable, etc.); various schemes to simplify the installation of distributed systems; the variation of margins and design standards; and the

increase in ship size and roominess to permit easier installation of equipment and outfit of the ship. Reference 1 provides a more comprehensive listing of concepts which could effect the ship layout.

The area of Preliminary Ship Layout is the most fertile area for producibility research for the naval ship designer. It is an area where he has substantial control (unlike Fleet Concept). It also occurs early enough in the design cycle to have impressive leverage to effect the ultimate design. For these reasons, the Authors concentrated their efforts to develop a producibility assessment methodology suitable for the early ship design phases.

Production Details

Once the general configuration and layout of the ship has been determined (usually fixed during late preliminary design and in some cases by early contract design), the design is refined and additional details developed. If a proposed producibility concept does not impact general arrangements, gross dimensions, shape, subdivision, or subsystem selection, but does impact component selection, material selection, internal compartment arrangements, the item belongs in the Production Details category of peacetime producibility. The tolerance guideline is that the change that follows from incorporation of the design option must be absorbable within the fixed ship configuration and within the design and construction‘ margins. The primary participating parties are the NAVSEA design team that typically produces the contract design, and the ship builder /design agent who refines the

contract design into the detail design.

Some example3 of producibility items that fall within the Production Details category include structural details, such as minimizing penetrations in bulkheads and minimizing lightening holes; standardization of structural panels; and simplifying piping runs and fabrication techniques. Certain material tradeoffs, such as the use of glass-reinforced-plastic (GRP) outfitting materials to minimize labor, or the substitution of High Strength Low Alloy (HSLA) Steel for High Yield Strength (HY-80) Steel also belong in Production Details. HSLA has very similar properties to HY-80, but is far easier to fabricate. Palletization might also fall within this category as a means of easing hookups and causing more shop vice shipboard manhours.

Shipyard As A Factory

If the proposed producibility item is not directly ship design dependent, but rather is a function of the physical plant of the production facility, the item belongs in the Shipyard as a Factory category of peacetime producibility. The primary participating party is the shipbuilder. Some examples of the Shipyard As A Factory category include zone outfitting, in which the ship is outfitted by region rather than by system; modular construction, where worker access and productivity is improved by use of hull modules which are later joined together; the development of test standards that support zone outfitting; computer-aided logistic3 and material `control; computer-aided working drawings; and production flow optimization. Many of the

techniques of the modern production line fit into this category, such as computer-aided manufacturing (CAM); process lanes or group technology, in which similar facets of different products are catalogued for the purpose of grouping together the manufacture of the different parts; and statistical process control, which is a near real-time measure of the effectiveness of the various Shipyard As A Factory techniques.

The Authors group these concepts in this category because the shipyard must commit to these concepts independent of a specific ship program. Of course once committed, the detail design of a specific ship will be affected, thus these concepts are closely linked with the Production Details category. In fact, consideration of these concepts must be made during the Preliminary Ship Layout phase as ship tightness and arrangements could also be affected.

Programmatic Strategy

If the producibility item is a business or acquisition strategy decision, having less to do with hardware and more to do with scheduling, methods of supply, and contracts, it belongs in the Programmatic Strategy category of peacetime producibility. It wi11 have little impact on the ship design and in some cases minor impact on the production facilities. These programmatic considerations can start with the first conceptual study and will not end until the 1ast ship is produced. The principal participating parties are the navy program office and the shipbuilders. Some examples of Programmatic Strategy include

whether material or equipment should be government furnished or shipbuilder provided; whether components should be single or multi-sourced; and the type of contract (fixed price, cost, incentive). The learning curve for ship production is an important factor. Therefore, the decision as to how large a particular ship class should be is vital. Mobilization considerations as to the location of production facilities, the availability of labor, and the workload distribution are additional examples of the Programmatic Strategy category of peacetime producibility.

Relationship Among Categories

All five of the above categories of peacetime producibility are closely related. The reasons why the Authors differentiated these categories is to focus attention on when and' by whom commitment decisions must be made. Figure 2 superimposes the phases of the ship design and construction process and the categories of ship producibility.

The fleet concept issues should be addressed prior to the start of a serious acquisition program. Producibility concepts which could effect ship layout must be decided upon before ship characteristics are frozen. Production details which can be absorbed into the fundamental design need not be addressed until contract and detail design. Programmatic issues and concept3 which impact the production facilities are closely related and must be part of an overall strategy.

PRODUCIBILITY ASSESSMENT METHODOLOGY

As previously explained, one of the reason3 why producibility is not more of a consideration during the early phases of the naval ship design process is due to the lack of a rigorous assessment methodology. The members of the design team are not familiar with the producibility issues nor with the trade-offs. One of the primary objectives of Bosworth's thesis was to develop such a methodology. This paper will summarize this assessment methodology and provide a case study to illustrate its use.

The Authors' assessment methodology consists of six steps as follows:

Step 1. - Characterize Concept. Certain information and data must be gathered and summarized in order to assess a specific producibility concept. Table 1 contains a convenient form for this task. The breadth and level of detail of this data must be consistent with the input required for the next four steps.

Step 2 - Ship Impact. A ship impact analysis is performed to determine the affect of the producibility concept on the ship's gross characteristics. This is generally performed using a ship synthesis model and for minor impact3 marginal cost factors. Bosworth [Reference l] discusses the advantages and disadvantages of five ship synthesis models currently being used to conduct ship impact analysis. A general treatment of the use of ship synthesis models can be found in Reference 4. ASSET Advanced Surface Ship Evaluation Tool, is capable of handling

most of the known probability concepts and was determined by the Authors to be the most suitable for ship impact analysis. For producibility concepts with minor impact on weight, internal volume, and manning, marginal factors can be used to determine the overall ship impact. This concept is discussed in References 5 and 6.

Table 2 provides a convenient form for summarizing the results of the ship impact analysis.

Step 3- Cost Impact. Since cost reduction is the primary motivation for considering producibility innovations during peacetime, a thorough cost analysis is required. Although all components of life cycle cost should be investigated, acquisition cost is the most visible cost category in this case. Most ship acquisition cost models consist of estimating the cost of each of the functional areas of the ship (categorized consistent with the Ship Work Breakdown Structure [SUBS]) using cost estimating relationships (CERs) for material and labor as a function of weight. These CERs are based on return costs of recent naval ships. Unfortunately these models are not sensitive to some the proposed producibility concepts since they are inconsistent with the shipbuilding approaches of completed ship acquisition programs. Some recommendations for improving cost estimating for Naval ships are provided in References 7 and 8. In these cases it will be necessary to include as part of the characterization of the concept, an analysis to determine the change to accepted cost estimating relationships. Table.3 provides a spreadsheet type of form to determine the cost impact of producibility

concepts.

step 4 - Effectiveness Analysis. The incorporation of a producibility concept into a baseline ship design could alter a performance characteristic such as spread, range, survivability, combat system effectiveness, and operability. However, the usual approach in conducting these types of assessments is to normalize performance features between the baseline and variant designs while conducting the ship impact analysis (Step 2). This is the cleanest way in as much as there will be no change in ship effectiveness and the net impact of the producibility concept will be on ship size and cost. Where it is inconvenient to normalize performance features, the differences should be noted. The Authors have not found any convenient effectiveness assessment models to utilize in these cases. This is a further motivation for normalizing performance.

Step, 5 - Risk Assessment. Any new concept incorporated into a ship design represents an increase in technical, schedule and cost risk. The degree of risk is for the most part evaluated qualitatively and categorized as low, medium, or high. A recent thesis by Walsh [Reference 9] provides a more rigorous approach to evaluating risk in naval ship designs and could be applied to the risk caused by new producibility concepts.

Step 6 - Net Assessment. An overall evaluation of the merits and shortcomings of a producibility concept will consist of all the considerations discussed in Steps 1 Though 5. The Authors have found no comprehensive methodology for combining 211

of the diverse considerations towards a single bottom line type of figure of merit. Table 4 provides a convenient form for summarizing the various considerations in a graphic format.

Since further details are provided concerning the assessment methodology in Bosworth's thesis, the Authors will move on to a brief discussion of a Case Study in order to further illustrate the procedure.

PRODUCIBILITY CASE STUDY

One example is provided to illustrate the viability of the producibility assessment methodology. The producibility concept chosen involves the issue of adding volume to a ship in order to increase the efficiency of installing equipment versus tightening up a ship to decrease ship size and thus materials. This has been a hotly debated issue in recent naval ship designs such as the just completed destroyer design, Arleigh Burke (DDG 51).

The specific volume reducing concept investigated was the deck height reduction approach involving reversing deck framing and reducing the clear deck height criteria. In this study, the baseline design contained the reduced deck height due to the reverse framing and reduced criteria and the variant contained the more volumetrically demanding conventional framing and expanded clear deck height. Thus this producibility assessment is between a volume reduction concept primarily for the purpose of ship weight reduction versus a more conventional shipbuilding approach which would appear to be more producible.

The steps in the producibility assessment methodology

discussed previously were followed. The results are summarized here with the more complete study available in Reference 1.

Step 1 - Characterize Concept. Using the Characterization Form suggested, the information to characterize the deck height producibility concept was gathered and summarized (see Table 5). The concept is described, a sketch provided (a picture is worth a thousand words) and the approach to conduct the ship impact assessment using ASSET is presented. The later step is important in the understanding and interpretation of the ship impact results as the Naval Architect must use judgement in modifying the baseline design. What is missing in this characterization is information on the affect on labor efficiency in installing equipment and distributed systems. This will be amplified in the discussion of Step 3.

Step 2 - Ship Impact Assessment. Before a ship impact assessment can be conducted, a baseline ship design must be in hand. In an acquisition project, the most current ship baseline serves as the basis for comparison. For this case study, a baseline needed to be synthesized. The baseline design was based on one developed as a ship design project at MIT and is similar to a baseline described by Goddard in his thesis [Reference 10].

For this ASW frigate, the payload contained a large conformal sonar array and a. towed array, vertical launch ASROC, Harpoon, Seasparrow, and three large Lamps III helicopters. The hull form was a Hull 23 variant, and the material for both hull and superstructure is high tensile steel (HTS). The baseline frigate has two gas turbine prime movers driving twin fixed pitch

propellers through an electric, water cooled, AC/AC transmission.

The ship impact assessment was carried out using the ASSET model and the results summarized in Table 6. The more volumetrically demanding deck height concept caused a 3 percent increase in total enclosed volume and increased displacement by about 2 percent. The major weight increases were in the area of structures and distributed systems. Almost 60 percent of the weight increase was in the shell and supports (SWBS 110) and deckhouse (SWBS 750).

Step 3- Cost Impact. As is almost always the case in ship design, cost data and cost analysis is difficult to develop. A set of CER's from ASSET and other cost models were utilized. In this case study, no real analysis was conducted to validate the modifications to certain of the CERs to reflect this producibility concept of increasing the 'ship's volume.* The CERs for labor (indicated as CERh in the form as opposed to CERm for material costs) which should be impacted by tightness are in the fundamental areas of SWBS 110, 120, 130, 150 (structure), 320 (electrical power distribution), 500 (auxiliary) and 600 (outfit). In this case study a slight reduction in the structural CER for labor was utilized but no change in labor cost per ton in the area of distributed systems and outfit. The end result (see Table 7) was a net increase in acquisition cost of 2 percent for the variant. This is simply because the increase in weight caused by the increase in volume of the ship was greater than the reduction. in labor rate that. might be expected when workers have more room to install equipment.

The Authors had no access to any shipyard data to indicate how efficiency could be enhanced by enlarging the ship volumetrically. As is the case in a real life acquisition project, the Cost Estimators are likely to retain conventional CERs unless there is overwhelming evidence to convince them that the CERs can be decreased. For this reason any producibility concept which tends to increase ship weight ends up increasing a cost estimate. This is why analysis of changes in CERs must be a part of every producibility characterization effort.

The issue of ship tightness is fundamental to many of the producibility concepts of the Ship Layout Category. The size and characteristics of the design are affected; therefore, the issue must be evaluated and assessed before the ship design is frozen. Figure 3 displays what intuitively one expects. As tightness is increased, ship displacement is decreased. Ship acquisition cost will decrease proportional to weight until the ship becomes so tight as to cause difficulty installing equipment, distributed systems and outfitting. As the tightness is further increased, the acquisition cost can actually increase.

This particular case study was chosen to illustrate what is often the situation. Producibility considerations are not included in an early stage design because of a lack of cost data to back up what intuitively one knows is right. No one really has a feel for the shape of the cost versus tightness curve of Figure 3. This is an area for fruitful investigation.

Steps 4 and 5 - Effectiveness and Risk. In this case- study performance was kept constant between the baseline and variant as

part of the ship impact assessment. Thus there is no appreciable difference in ship effectiveness.

In the area of risk there is also no appreciable difference, Any concept which tightens up the design tends to increase risk slightly. As is usually the case the degree of risk is in the eye of the beholder.

Step 6. - Net Assessment. The overall evaluation of this particular producibility concept of increasing deck heights is summarized in Table 8. The baseline concept of a slightly smaller deck height and therefore smaller ship is better in the categories of ship weight, volume and acquisition cost. The more voluminous baseline has advantages in operability (easier for crew to operate and maintain a looser ship) and risk. All other categories are basically equal.

If this were a real acquisition program where cost is constrained, the decision would be no doubt to stick with the baseline concept. In this case the lower acquisition cost of the baseline might not be true due to the lack of realistic cost estimates. The cost. impact of producibility concepts must' be researched thoroughly as part of the categorization effort.

SUMMARY AND RECOMMENDATIONS

A number of conclusions and recommendations should be noted from this study:

-Producibility is currently not a significant consideration in naval ship design.

- In order to be ready for a mobilization effort, it is recommended that several simple, highly producible mobilization designs be produced through the detailed design level. Furthermore the more promising of these designs should be selected and prototypes constructed to validate the design. These low mix ships could serve in the reserve fleet, be used for training and for testing.

- To increase the awareness of producibility as an important design element for the Navy's ongoing ship design and acquisition programs, a rigorous assessment methodology needs to be developed. Such a methodology consisting of six steps has been proposed. A Ship Producibility Handbook should be prepared describing this assessment methodology and made available to ship design teams. An important part of this handbook would be a file of characterizations of known producibility concepts. The most important part of these characterizations is a fundamental cost analysis of each concept indicating how cost estimating relationships used in cost models should be modified to reflect the concept.

- A Producibility Advocate will be required to ensure that producibility is a significant consideration in naval ship design and acquisition. No such position exists today. Without such a strong visible Advocate little will be accomplished in this area.

REFERENCES

Bosworth Michael L., "Producibility As a Design Factor in Naval Combatants," M.I.T. Ocean Engineering Thesis, June *1985.*

2. Connery, Robert, The Navy and the Industrial Mobilization In WWII, Princeton University Press, 1951..

3. Lane, Frederic C., ships for Victory - A History of. Ship-building Under U.S. Maritime Czmmssion in World War II, John Hopkins Press, **1951.**

4. Devine, M., Beyer, C., Tsao, S., "ASSET: Advanced Surface Ship Evaluation Tool Manual", Boeing Computer Services, **1983.**

5. Graham, Clark, "The Impact of Subsystems on Naval Ship Design," Naval Engineers Journal, , December 1985.

6. Howell, J., Graham, C., "Marginal Weight Factors for Surface Combatant Ships," 13th Annual Technical Symposium of Associations of Scientists and Engineers of the Naval Sea Systems Command, 1976.

7. Drewey, John T., "Cost Estimating - A Crucial Function of the Ship Acquisition Process," Naval Enaineers Journal, April **1976.**

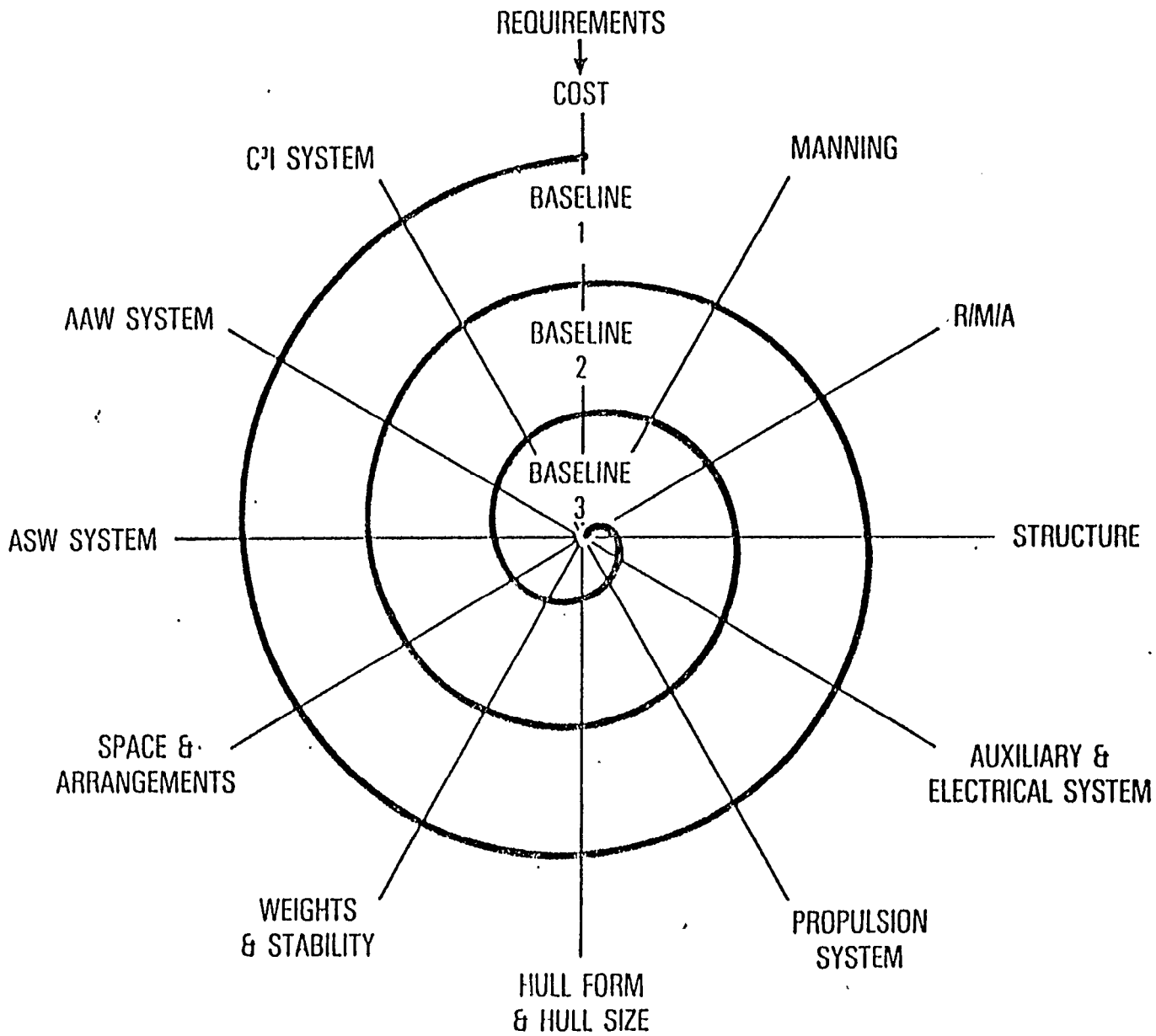
8. Hope, J.P., stoutz, v., "Warships and Cost Constraints," 22nd Annual Technical Symposium of Association of Scientists and Engineers of the Naval Sea Systems Command, 1985.

9 . Walsh, *S e a n* P"An, Improved Method of Risk Analysis for the Naval Ship Design Process," M.I.T. Ocean Engineers Thesis, June 1985.

10. Goddard, Charles H., "A Methodology for Technology Characterization and Evaluation for Naval Ships," M.I.T. Ocean Engineers Thesis, June **1985.**

FIGURE 1

ITERATIVE DESIGN PROCESS



PEACETIME PRODUCIBILITY CATEGORIES

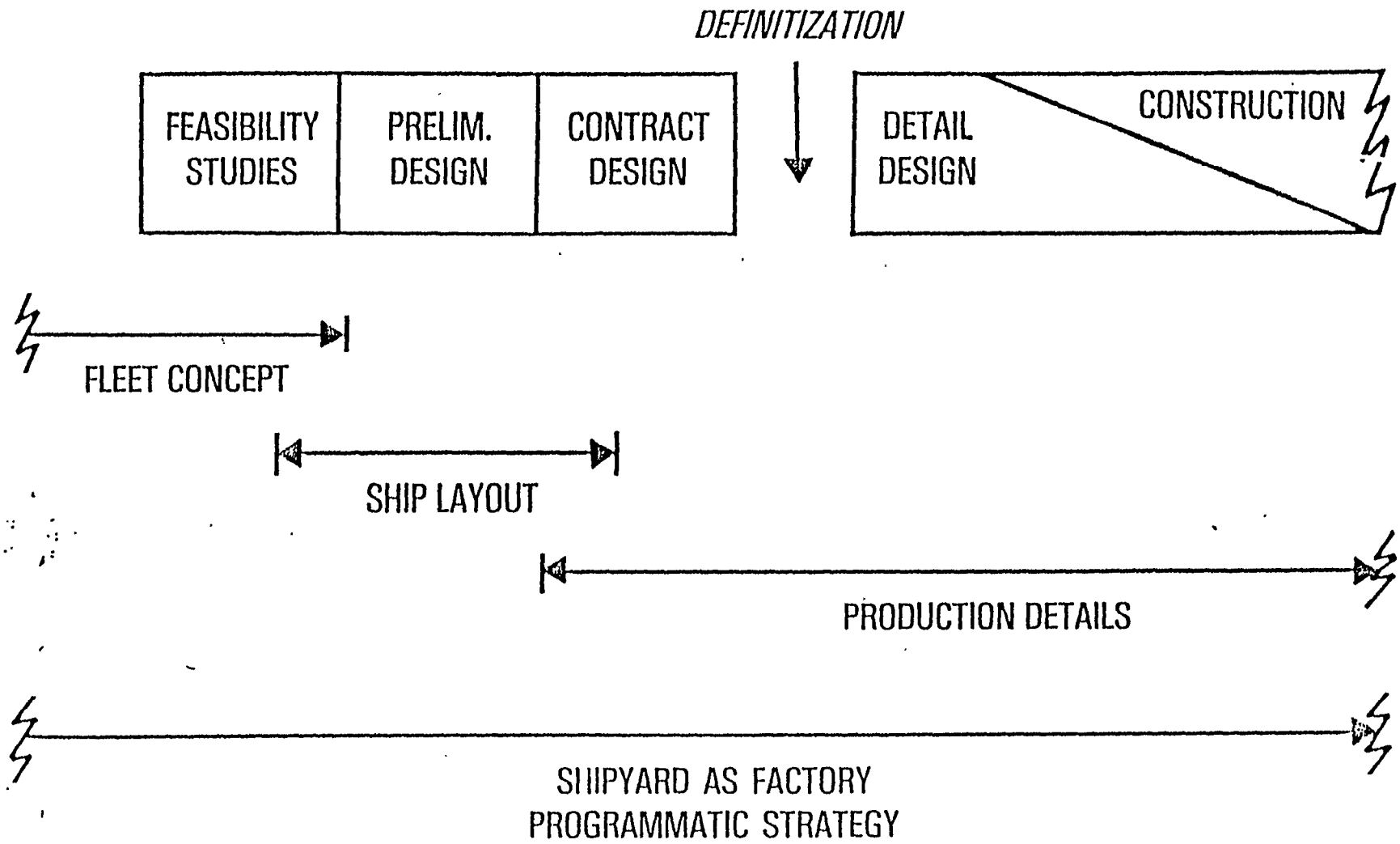


FIGURE 3

SHIP LAYOUT EXAMPLE - TIGHTNESS

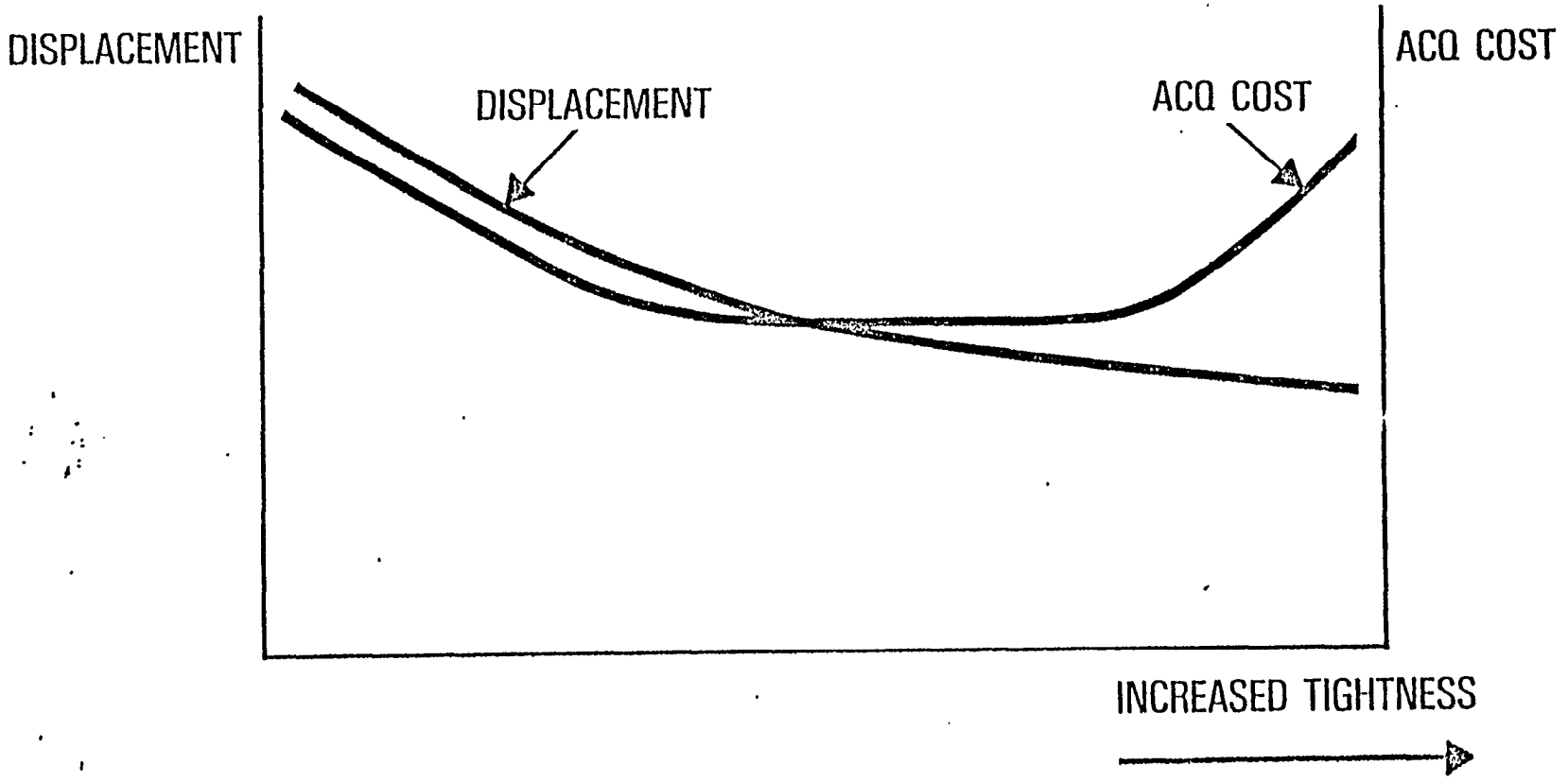


TABLE 1

PRODUCIBILITY CHARACTERIZATION

Producibility Concept Definition Ship:_____ Item:__

Concept:_____ Ref:___

Description and direct (first order) changes. Include weight,volume,cost,geometry,power,manning.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Tradeoffs between baseline and concept variant. Where will the concept gain and lose?

_____
_____
_____
_____

baseline

variant

Translation to Assessment Tool

Record of ASSET Changes . . . item	baseline	variant
(1)		
(2)		
(3)		
(4)		
(5)		
(6)		
(7)		
(8)		
(9)		
(10)		

Rebalancing Comments:_____

_____
_____
_____

TABLE 2

PRODUCIBILITY SHIP IMPACT

Ship Characteristics Impact Ship:_____ Item: ___
Concept:_____

parameter	abbrev	(dim)	baseline	variant	delta	percent
Length at waterline	LWL	(feet)				
Length between perpendiculars	LBP	(feet)				
Beam at waterline	B	(feet)				
Depth amidships	D	(feet)				
Draft	T	(feet)				
Displacement, full load	Δfl	(LT)				
Volume of hull	∇h	(k ft^3)				
Volume of deckhouse	∇dh	(k ft^3)				
Total Volume	∇t	(k ft^3)				
Stability measue	GM/B	(-)				
Total electical load	KW tot	(KW)				
Main contin. power available	IP	(hp)				
Manning	M	(men)				
Maximum sustained speed	Vs	(kts)				
Endurance speed	Ve	(kts)				
Range	R	(nm)				
Payload	W payld	(LT)				
Margins						
SWBS Group						
100 Hull Structure	W1	(LT)				
200 Propulsion Plant	W2	(LT)				
300 Electrical Plant	W3	(LT)				
400 Command and Surveillence	W4	(LT)				
500 Auxiliary Systems	W5	(LT)				
600 Outfit and Furnishings	W6	(LT)				
700 Armament	W7	(LT)				
Weight of D+B margin	Wm	(LT)				
LIGHTSHIP WEIGHT	W ltshp	(LT)				
Fuel & Lubricant weight	Wf	(LT)				
Ordnance Load weight	Wa	(LT)				
Other Load weight	Wo	(LT)				
FULL LOAD WEIGHT	W fl	(LT)				

Weight of primary 2-digit SWBS . . .

name	subgroup

note:small apparent summation errors are due to display roundoff.

TABLE 3

PRODUCIBILITY COST IMPACT

Ship Cost Impact (FY85 $) Ship: _____ Item:__

Concept: _____

SWBS No.	Description	Baseline Weight	Baseline CERa	Baseline CERh	Variant Weight	Variant CERa	Variant CERh	Baseline Cost,k$	Variant Cost,k$	k$ delta	percent
11/12/13	HullMatl A										
11/12/13	HullMatl B										
15	DkhsMatl A										
15	DkhsMatl B										
162	Stacks										
171	Masts										
1X	Rest,Grp 1										
23 (hp)	Propul Units										
241	Reduc Gear										
243	Shafting										
244	Bearings										
245	Propellers										
25	Support Sys										
26	Sup Sys-FO,LO										
2X	Rest,Grp 2										
31 (hp)	ElecPowerGen										
32	Power Distrib										
3X	Rest,Grp 3										
4	Command										
5	Auxiliary										
6	Outfit & furn										
7	Armament										
	D&B Margin										
	LIGHT SHIP		na	na		na	na				
8	Engineering	ditto			ditto						
9	Assembly	ditto			ditto						
ACQ.CONSTRUCTION COST		na	na	na	na	na	na				

Weights for alternate costing SWBS No.

SWBS No.	Description	Baseline	Variant
23	Propul Units		
31	ElecPowerGen		

SWBS No.	Description	Baseline	Variant	Z
11/12/13	Hull Matl$			
15	Dkhs Matl$			

ACQ.CONSTRUCTION COST
plus profit Z:

ACQ.CONSTRUCTION PRICE
plus change orders
plus NAVSEA support
plus post delivery
plus outfitting
plus H/M/E + growth
plus payload cost

notes: acquisition costs are for follow ship.O+S and LCC are for 30 ships w/ 30 year life.

UNIT SAILAWAY ACQ COST (k$)
OPER+SUPPORT SYSTEM COST ($M)
AVG LIFE CYCLE COST/ship ($M)

TABLE 4

PRODUCIBILITY NET ASSESSMENT

Summary Ship:_____ Item:__

Concept:_____

Impact	Comments	baseline better (-------			equal		variant better -------)
Weight	_____						
Volume	_____						
Stability	_____						
Elec Power	_____						
Manning	_____						
Combat System Effectiveness	_____						
Mobility	_____						
Survivability	_____						
Operability	_____						
Acquisition Cost	_____						
Operating and Support Costs	_____						
Life Cycle Costs	_____						
Risk	_____						
Other:_____							

Bottom Line:_____

TABLE 5

PRODUCIBILITY CHARACTERIZATION

Producibility Concept Definition Ship: BGASWFF Item: 1

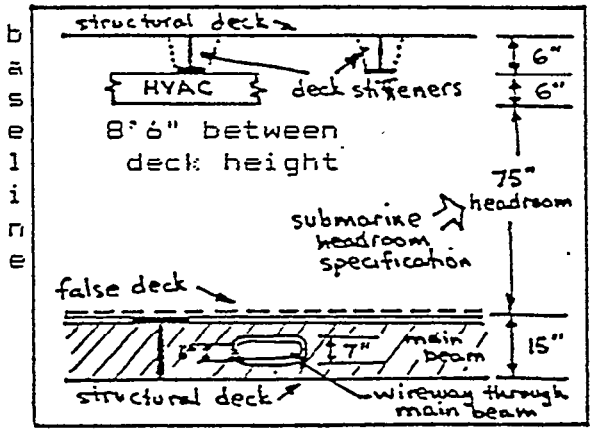
Concept: Deckheight reduction w/ reverse framing Ref:116

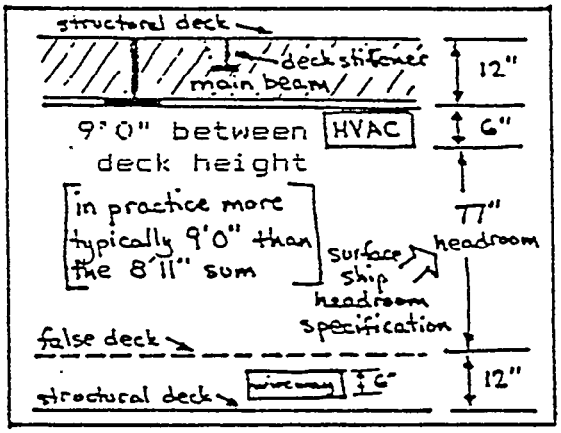
Description and direct (first order) changes. Include weight, volume, cost, georetry, power, ianning.

By using submarine headroom standards (75") and reverse framing (transverse stiffener5 and longitudinal stiffeners on opposite sides of the structural deck they stiffen) deck-height in criticalfa1se decked electronic5 spaces can be reduced from 9'0" to 8'6". System envelope5 (wireways, HVGC) remain constant at 6" deep each, weight stays the same, the material cost is constant, labor cost5 of the reduced deck-height version is 5% higher (cutouts in main beam for stif-feners in variant approxequal to cutout for wireway for the baseline. No manning or power changes. ----------

Tradeoffs betnoen baseline and concept variant. Where will the concept gain and lose?

The reduced deckheight will reduce overall ship volume, and the smaller ship should cost less. However, the slightly in-creased labor cost5 of the 9' variant will offset this some. Headroom suffers only in elex spaces (77"->75"). ----------





Translation to Assessment Tool

Record of ASSET Changes . . . item

item	baseline	variant
(1) Hull Deck Location Array	29.5,21,12.5,4	29,20,11,2 *
(2) Deckhouse Height Array	8.5,17,8.5,8.5	9,18,9,9
(3) Deckhouse Average Deck Ht	8.5	9.0
(4) Hull Matl A CER for manhrs	4.6	4.52 **
(5) Deckhs Matl A CER for manhrs	7.4	7.22 ***
(6)		
(7)		
(8)		
(9)		
(10)		

Rebalancing Comments: *After intial balance, adjust up for increased hull size. ** Deck 56% of Hull Mat1 A. ***Deck 50% of tota1 deckhouse. (sample: .36 x.05 = 018; l/l.018 = 982 CERmt = 4.6 x .982 = CERmv = 4.52) baseline=RUBBER.BL.BAL

TABLE 6

PRODUCIBILITY SHIP INPACT

Ship Characteristics Impact — Ship: BGASWFF — Item: 1
Concept: Deckheight Reduction w/ reverse framing; baseline=8'6", variant=9'0"

parameter	abbrev	(dim)	baseline	variant	delta	percent
Length at waterline	LWL	(feet)	427	430	2.80	.66
Length between perpendiculars	LBP	(feet)	427	430	2.80	.66
Beam at waterline	B	(feet)	50	51	.33	.66
Depth amidships	D	(feet)	38	38	.25	.65
Draft	T	(feet)	18.83	18.96	.13	.69
Displacement, full load	Δ fl	(LT)	5558	5669	110.20	1.98
Volume of hull	∇ h	(k ft^3)	558	569	11.06	1.98
Volume of deckhouse	∇ dh	(k ft^3)	108	116	7.92	7.30
Total Volume	∇ t	(k ft^3)	667	686	18.98	2.85
Stability measue	GM/B	(-)	.1027	.0989	.00	-3.70
Total electical load	KW tot	(KW)	4105	4133	28.10	.68
Main contin. power available	IP	(hp)	52209	52514	305.00	.58
Manning	M	(men)	301	301	.00	.00
Maximum sustained speed	Vs	(kts)	27.95	27.95	.00	.00
Endurance speed	Ve	(kts)	20.00	20.00	.00	.00
Range	R	(nm)	4500	4500	.00	.00
Payload	W payld	(LT)	970	970	.00	.00
Margins					.00	
SWBS Group						
100 Hull Structure	W1	(LT)	1305	1370	65.30	5.00
200 Propulsion Plant	W2	(LT)	429	434	4.70	1.10
300 Electrical Plant	W3	(LT)	252	256	4.10	1.63
400 Command and Surveillence	W4	(LT)	650	651	1.20	.18
500 Auxiliary Systems	W5	(LT)	640	650	10.80	1.69
600 Outfit and Furnishings	W6	(LT)	397	403	6.50	1.64
700 Armament	W7	(LT)	130	130	.00	.00
Weight of D+B margin	Wm	(LT)	475	487	11.60	2.44
LIGHTSHIP WEIGHT	W ltshp	(LT)	4278	4382	104.20	2.44
Fuel & Lubricant weight	Wf	(LT)	1010	1016	5.90	.58
Ordnance Load weight	Wa	(LT)	144	144	.10	.07
Other Load weight	Wo	(LT)	127	127	.00	.00
FULL LOAD WEIGHT	W fl	(LT)	5558	5668	110.20	1.98

Weight of primary 2-digit SWBS . . .

name	subgroup				
Shell and supports	110		389	443	54.20	13.93
Deckhouse structure	150		158	173	15.10	9.56

note:small apparent summation errors are due to display roundoff.

TABLE 7

PRODUCIBILITY COST IMPACT

Ship Cost Inpact (FY85 $) Ship: BGASYFF Item: 1
Concept: Deckheight reduction M/ reverse framing; baseline=8'6', variant-9'0'

SWBS No.	Description	Baseline Weight	Baseline CERa	Baseline CERh	Variant Weight	Variant CERa	Variant CERh	Baseline Cost,k$	Variant Cost,k$	k$ delta	percent
11/12/13	HullMatl A	875.9	3.6	4.6	920.9	3.6	4.52	7182	7478	295.328	4.11
11/12/13	HullMatl B	0	0	0	0	0	0	0	0	0	.00
15	DkhsMatl A	158.3	5.5	7.4	173.1	5.5	7.22	2042	2202	159.762	7.82
15	DkhsMatl B	0	0	0	0	0	0	0	0	0	.00
162	Stacks	31	5.5	7.4	32.8	5.5	7.4	400	423	23.22	5.81
171	Masts	10.7	5.5	7.4	11.3	5.5	7.4	138	146	7.74	5.61
1X	Rest,Grp 1	228.8	2.9	4.3	231.9	2.9	4.3	1647	1670	22.32	1.35
23 (hp)	Propul Units	52209	.41	.15	52512	.41	.15	29237	29407	169.68	.58
241	Reduc Gear	0	6	4	0	6	4	0	0	0	.00
243	Shafting	78.7	31	4	79.7	31	4	2755	2790	35	1.27
244	Bearings	14.6	32	4.5	14.8	32	4.5	533	540	7.3	1.37
245	Propellers	31.8	2	4	31.9	2	4	191	191	.6	.31
25	Support Sys	65.2	50	10	67.2	50	10	3912	4032	120	3.07
26	Sup Sys-FO,LO	24.7	35	9	24.8	35	9	1087	1091	4.4	.40
2X	Rest,Grp 2	10.7	30	5	10.7	30	5	375	375	0	.00
31 (hp)	ElecPowerGen	4105	.86	.63	4133	.86	.63	6116	6158	41.72	.68
32	Power Distrib	92.8	20	40	95.3	20	40	5568	5718	150	2.69
3X	Rest,Grp 3	63.2	20	40	64.2	20	40	3792	3852	60	1.58
4	Command	650.2	15.6	23	651.4	15.6	23	25098	25144	46.32	.18
5	Auxiliary	639.6	28.5	19.3	650.4	28.5	19.3	30573	31089	516.24	1.69
6	Outfit & furn	396.9	12.3	24.2	403.4	12.3	24.2	14487	14724	237.25	1.64
7	Armament	130	3.6	7	130	3.6	7	1378	1378	0	.00
	D&B Margin	475.3	35.9	0	486.9	35.9	0	17063	17480	416.44	2.44
	LIGHT SHIP	4277.7	na	na	4381.9	na	na	153573	155887	2313.32	1.51
B	Engineering	ditto	0	6.62	ditto	0	6.62	28318	29008		
9	Assembly	ditto	0	9.02	ditto	0	9.02	38585	39525		
ACQ.CONSTRUCTION COST		na	na	na	na	na	na	220477	224420	3943	1.79

Weights for alternate costing SWBS No.

SWBS No.	Description	Baseline	Variant
23	Propul Units	203.3	204.6
31	ElecPowerGen	96	96.6

SWBS No.	Description	Baseline	Variant	%
11/12/13	Hull Matl$	3153.24	3315.24	5.14
15	Dkhs Matl$	870.65	952.05	9.35

	Baseline	Variant	delta	percent
ACQ.CONSTRUCTION COST	220477	224420	3943	1.79
plus profit %: 8	17638	17954	315	
ACQ.CONSTRUCTION PRICE	238115	242373	4258	1.79
plus change orders	19049	19390	341	
plus NAVSEA support	5953	6059	106	
plus post delivery	11906	12119	213	
plus outfitting	9525	9695	170	
plus H/M/E + growth	23811	24237	426	
plus payload cost	276200	276200	0	
UNIT SAILAWAY ACQ COST (k$)	584559	590073	5515	.94
OPER+SUPPORT SYSTEM COST ($M)	31221	31289	68	.22
AVG LIFE CYCLE COST/ship ($M)	1706	1711	5	.29

notes: acquisition costs are for follow ship.O+S and LCC are for 30 ships w/ 30 year life.

TABLE 8

PRODUCIBILITY NET ASSESSMENT

Summary **Ship: EGASWFF--** Item:1

Concept: Deckheight reduction w/ reverse framing

Impact	Comments	baseline better		equal		variant better
Weight	variant weighs more		X			
Volume	variant:vol deficient	X				
Stability				X		
Elec Power				X		
Manning				X		
Combat System Effectiveness				X		
Mobility				X		
Survivability				X		
Operability	lower overhd in BL could limit rigging access				X	
Acquisition Cost	due reduced size of the baseline		X			
Operating and Support Costs	baseline better.but not statis. significant			X		
Life Cycle Costs	BL better.but not statistically signif.			X		
Risk	both are low risk. variant is standard practice			X		
Other:	BL concept: some question re: transition from false deck to non-false-deck. However, difference in height is only 3" more than the variant.			X		

Bottom Line: The baseline, with 8'6" deckht, is almost 2% better in acq cost w/ no significant penalties.

PANEL SF-5

HUMAN RESOURCE INNOVATION

Frank Long
Bethlehem Steel Corporation

Chairman

MULTI-SKILLED WORK TEAMS IN A ZONE CONSTRUCTION ENVIRONMENT

BY

Dan Stravinski
Manager of Personnel Programs

Sational Steel and Shipbuilding Company

ABSTRACT

In order to address the problems inherent in a trade oriented production organization, and to develop a work force which will perform efficiently and effectively in a zone construction environment, NASSCO has proposed to deveiop semiautonomous, multi-skilled work teams.

The teams will be made up of a stable membership, be well trained, have multiple skills, and will have some degree of control over decisions necessary to complete work in their areas.

One supervisor, rather than individual trade supervisors will be responsible for completion of work within the area. Employee participation will be encouraged to the greatest possible extent. Although ultimate authority for decisions within the work area will remain with the supervisor, it is envisioned that the traditional role of supervision will shift in emphasis from "boss" to facilitator acting as liaison between the work team and other parts of the organization.

MULTI-SKILLED WORK TEAMS IN A ZONE CONSTRUCTION ENVIRONMENT

PRESENTATION TO THE NATIONAL SHIPBUILDING RESEARCH PROGRAM SYMPOSIUM

Thursday, September 12, 1985
Hyatt Regency Hotel, Long Beach, California

Good morning Ladies and Gentlemen my name is Dan Stravinski. I am Manager of Personnel Programs at National Steel and Shipbuilding Company and I am here to report on National Steel's experience with Multi-Skilled Work Teams in a Zone Construction Environment. A little background might help in understanding our experience. at NASSCO.

In about mid 1984 a request for proposal was distributed to members of the SP-5 Panel. The proposal had as its objective the development and testing of a new production work force organization that would fit the technical requirements of product oriented work breakdown structure - otherwise known as zone construction- This new production work force organization was to incorporate advantages claimed for multi-skilled, self-managing work teams. Elements of these teams included fairly continuous association of team members, multiple skills and some degree of self-management. The concept was one of some interest to NASSCO as we are in the process of converting from the conventional systems approach to shipbuilding to zone construction. The multiple skilled dimension of the work team presented a problem for us at the time the request for proposal was first received. Fortunately, NASSCO was preparing for negotiations with its 7 unions during the same time frame. Up until this time, our labor agreements were like many others; they provided for separate classifications, with well defined limits on what work these classifications could do.

NASSCO Management saw the necessity of allowing increased flexibility in the use of production trades if the full benefit of zone construction techniques was to be realized. To this end, a number of meetings were held with our Union representatives prior to negotiations to bring them up-to-date on the technological changes that were taking place in shipbuilding and he need for our work force organization to change accordingly. In order to further emphasize this point, a group of selected union representatives were invited to travel to Japan with members of NASSCO's production organization to view first hand the effectiveness of these techniques, as well as how they were accomplished.

Negotiations for new labor agreements began shortly after the group's return from Japan. Although there were many disagreements along the way, the parties approached the issues in a problem solving mode, such that each side at least understood the position of the other.

I would like to say that at the end of negotiations full agreement was reached on allowing increased flexibility within the production trades, however, this was not the case. The various unions involved were unable to agree on the details of our proposed understandings, therefore, the Company's position on work rule changes was included as a part of its final proposal to the unions to be voted upon by their membership.

Although complete agreement on work rule changes was not reached among

all of our unions, the Company's final proposal did attempt to address the concerns raised by our unions during discussions on the Company's proposed changes.

During these ‘negotiations our union representatives recognized the changes taking place in the shipbuilding industry and attempted to deal with the effects of these changes as best they could, while still protecting the interests of their members. We feel the final modifications to our work rules reflect the best thinking of both parties regarding this issue.

At this time, the Company, in addition to the changes in work rules, was proposing a wage freeze. The Company's final offer was voted down and a two week strike. ensued. After additional money was made a part of the Company's proposal, the offer was ratified and the strike ended. The Company's final position on work rules was unchanged and is now part of our labor agreements.

The basic changes in work rules negotiated by NASSCO were two-fold. First, changes were negotiated which would allow a tradesperson to perform work that was incidental to their normal trade - an example of this would be a pipefitter being allowed to use the welding/burning processes to cut pipe hangers to length and tack them into position.. In the past only welders could do this work. Other changes were more far reaching and involved the establishment of classifications which were much more broadly defined than those of the past. An example of this is the classification of outfitter. A member of this classification can perform any work of the pipefitter, outside machinist

or boiler machinist classifications, in addition to using the welding and burning processes on work incidental to their main task.

These changes were particularly important when viewed in the context of on-unit or on-block construction, where most work necessary to complete the unit or block would be performed in given area. NASSCO wanted individuals who could perform most, or all of the work associated with a given unit or block. The new work rules provided us with this flexibility. In addition to work rule changes agreed to in our 1984 labor negotiations, certain flexibility in assignments already existed in our labor agreements. For example, employees within our Ironworkers Union, who represent metal working trades in the yard could be temporarily assigned to perform the work of another classification for a limited period of time; also, shipfitters could be assigned to perform any welding or burning for which they were qualified. NASSCO was fortunate enough to have work on the books at the time these changes took place. Two tankers were being converted to hospital ships and an order had just been received from EXXON for two new oil tankers. Although some aspects of zone construction were to be used in completing the hospital ship contract it was contemplated that the construction of the EXXON tankers would be based entirely on the principles of zone construction. This transition reached from Engineering through Materials to the tradesperson in the yard. It included stage of construction working drawings, material installation instructions, and pallet material lists developed by teams of production planners and production staff engineers. Given this background it is not surprising that NASSCO submitted a proposal to examine multi-skilled work teams in a zone construction environment since we now had the capability of fully exploring the concept.

In devaloping our proposal, two factors on the human relations side were identified as inhibiting productivity in the American shipbuilding industry. The first of these factors was the traditional system design approach utilized by engineers., owners and regulatory agencies. This particular factor, of course, is addressed by moving to a zone construction method of shipbuilding.

The second factor, and one that we are concerned with in this instance, is the development of a work force which traditionally has been composed of highly specialized workers with a relatively narrow range of skills or duties. These two factors interact to produce low productivity for a number of reasons.

Vu Graph #1, First, a lead trade would have to cease work if a support trade was not available to perform a task incidental to the job. For example, at NASSCO if a pipefitter was performing his job but a welder was not available to cut pipe hangers and tack them in place, the pipefitter would be prevented from going any further on the job.

Secondly, significant wait time was experienced if the work of a lead trade and **a** support trade was not evenly distributed and coordinated. In the example of the pipefitter and pipe welder without good coordination, the welder may have spent most of his time idle, while the pipefitter was fitting the next run of pipe.

Thirdly, organization of work along trade lines resulted **in the** development of trade oriented supervision. This type of organization is not conducive to the development of a cooperative approach to getting

the job done. At times, supervision had to go through two different organizational levels before a common supervisor was reached who could resolve a conflict. Too frequently- emphasis was placed on having the work of one trade completed, regardless of how the performance of this work might impact another trade in the performance of its work.

Finally, trade orientation in the work force also results in excessive movement of man power. Employees of a given trade would be assigned to perform a task, and when that task was completed, they would be assigned to another vessel or area of the yard. This continual movement of man power was not conducive to the development of smooth working relationships, either among the trades themselves, or between a trade and their supervisor.

Vu Graph #2. In order to address these problems NASSCO proposed that seams be developed that would have stable membership, be multiskilled and well trained. A high degree of employee participation would be encouraged, and to the extent possible, the team would be responsible for decisions necessary to complete work in their area.

In order to eliminate difficulties associated with trade oriented supervision, one supervisor would be responsible for completion of work in the area. In the event technical assistance was required in a trade that the supervisor was not familiar with, a leadman or working foreman from that trade would provide such assistance.

It was envisioned that the role of the supervisor in charge would also change from that of "boss" to one of facilitator where they would

act as a liaison between the work team and other parts of the organization, such as Maintenance, Materials, etc. Ultimate authority would still rest with the supervisor.

In addition to the elements just described, the intent was to provide as much information to the team as possible, to make them fully aware of what was involved in the task before them.

It was hoped that having a team with a stable membership would allow the development of working relationships among team members which would increase production efficiency.

In order to make sure that employees had the necessary skills to come up with solutions to the problems they might encounter, training in problem solving would be provided. Through their participation it was hoped that team members would take greater ownership in the production process with increased productivity and job satisfaction the result.

Other companies and industries have successfully experimented with this approach, ranging from Volvo in Sweden to shipyards in Europe and automobile assembly plants in the United States.

In determining where such a team would operate, a site where the work process was discrete enough to examine was desired. The site also had to be one where some multi-skilling could take place. A steel assembly table was chosen for the initial team. The area referred to as Table 9 was designated to build mid-body sections for the EXXON

tankers with use of jigs and fixtures permanently installed in the area. It was felt that teams working on these units would have an opportunity to develop skills in the area of welding, burning, shipfitting, blueprint reading, layout and others.

In order to determine those individuals who would become team members, representatives of the Personnel Department submitted a list of names of individuals who had expressed interest in the project to the production superintendent in the area. Most of the individuals suggested had had previous experience in teams and small groups through the Company's Quality Circle Program. These lists were reviewed and modified, with the final selection of employees to work on the table being made by the production superintendent.

An initial group of employees were identified and assigned to the table, and as work picked up in the area, other individuals were assigned as needed. Second and third shifts were added later on. In order to have a true test of this different method of organization it was realized early on that all shifts had to be involved since it would be difficult to determine increases in productivity if not all employees working on the project were involved as team members.

Vu Graph #3. Once a core group of employees were identified, an orientation session was held to bring the participants up-to-date as to what the Company intended to do in this area and the employee's role in it. The orientation session was held off-site at a local hotel and included all of the trades which would be responsible for producing units on Table 9, as well as the supervision who would be

responsible for the area, and the project management team.

Details of the team operation, as well as the objectives of the project were covered. Employees were given some idea of the technical aspects of Table 9 operation, including how the work would flow through the area, and the jigs and fixtures which had been constructed to help produce the units in the area. Some training was conducted in communication and brainstorming skills, and a brainstorming session was held to identify initial issues of interest for the group. These included; shift turnover and coordination, training, safety, equipment issues, housekeeping, and the information they felt was required for them to complete their work in an efficient manner. Initial interviews were also conducted with the group to get some idea of how team members felt about being a part of the project and what they hoped to get out of it.

In all, seven hours on a Saturday were spent by team members in this orientation session. It was a very positive meeting with all involved indicating a desire to give the new organization a try and see how it worked.

Which raises the $64,000 Question - How has it worked? The immediate answer to that question is the jury is still out. The team has been in operation less than three months, with the 2nd shift only now becoming stable enough to have them begin operating as a part of the work team project. It has been quite a learning experience though. As with any new system, we had our share of miscommunication and foul-ups, however, most of them seem to be behind us now and the team is beginning to gel and get on with the task at hand.

We have a first shift crew of approximately 22 welders, shipfitters, and supervision. Each day a start-of-shift meeting is held to communicate pertinent information to team members, as well as to allow feedback from the team members to the supervisor conducting the meeting. In addition to these start-up meetings, a one hour meeting is held each week to discuss issues of concern to the team, as well as to provide training in problem solving and other aspects of group dynamics and technical training.

One supervisor is in charge of the team. We are fortunate to have the individual who was chosen as supervisor for this area in that he is open to new methods of organization after having spent six months in Japan observing ship construction methods in their yards and observing work force organization there.

Vu Graph #4. The work team has been as stable as teams of this nature get in shipbuilding, in that most of the members who were present at our Saturday orientation session in June 1985, are still with the team. Due to fluctuating man power requirements on the table, there are times when team members are assigned to different areas in the yard, however, we have been successful in having these employees returned to the table at such time work is again available for them.

An attempt has been made to encourage employee participation on the part of team members. Information regarding schedules, stage plans and blueprints have been made available to team members for their review. A chalkboard has been put up in the area to allow communication between shifts and a bulletin board has been added to allow posting of information pertinent to the team.

Vu Graph #5 . A number of suggestions have been made by team members to help the team become more efficient, such as having team members paired as a work group within the team so that over a period of time a smooth working relationship could be developed, with increased productivity and job satisfaction the result.

A suggestion was made to have members work on a unit from the fabrication of web frames on until the unit is complete so the work is less monotonous and the people have a better idea of what it is they are constructing.

Team members have also suggested that attempts be made to limit re-assignment of individuals from Tabie 9 to other areas of the yard by having them perform work in other classifications. For example a welder might be assigned to shipfitting work or a shipfitter to welding.

These suggestions fit in well with our objective of providing employees in the area with multiple skills. Welders have been assigned to shipfitting tasks and shipfitters have been assigned to welding tasks in order to bring their skills up to par in these areas, as well as to limit the amount of re-assignment required depending on work load.

addition to the on-the-job training just described, classroom training is also being offered. The Company has ongoing blueprint reading classes which team members are encouraged to attend. To date approximately five individuals have taken advantage of this opportunity, Team members have been provided with some training in problem solving with more to come. Additional training will take place as needs are defined.

In order to give them a 'better idea of the context in which their work is taking place a suggestion was also made to have a video tape made of completed units being erected so that team members can see where their product is being utilized in the construction of the ship, as well as to document any problems caused by inaccurate work.

The autonomy of team members is a subject that is still being explored with no firm ground rules yet established. A good deal of autonomy was given the initial group of employees assigned to the Table 9 area, however, as other shifts were added and the production process became more complex significant autonomy was more difficult to allow.

Team members have expressed a desire for greater say in how the job is accomplished, who they work with, and what assignments they must undertake. A process has been established to attempt to resolve some of these questions. Team members are encouraged to bring up questions of this type in our one hour meeting each week and at that time responses are provided immediately as to what the Company is willing to do, or the issue is reviewed and a response is provided at the following meeting.

Vu Graph #6. The one hour meetings have proven to -be a challenging aspect of team operation. A number of issues have been brought up that needed to be dealt with prior to the time members actually felt willing to move forward with the process. As you would expect, some of these issues were physical needs, ranging from lockers, to having time clocks placed in a more convenient area. Other issues included clarification of the role supervision was to play on the table.

team members apparently expected a greater degree of autonomy and much less supervision than what is actually taking place. The question of incentives has been raised. Some individuals on the team feel that if the Company is expecting them to perform work in a different manner, or take on more responsibility, that they should, in turn, be rewarded for their efforts. Problems have arisen due to the vagaries of production itself, such as; late material, or problems with other shifts screwing up a job requiring rework by 1st shift. One of the more disruptive situations occurred when the regular supervisor in the area took a week off to get married, and the individual who took his place was not properly oriented as to the ground rules for team operation and the relationship between team members and supervision in the area. As the result of this, some team members felt betrayed and some time had to pass before they were again willing to work as team members.

Other issues have been raised as well. Team members have expressed concern that by blazing the trail of multi-skilling they would, in turn, be blamed by their co-workers for developing a work process which would eliminate jobs. Our Ironworker's Union has some concern for this reason as well.

Although representatives of the Ironworker's Union were invited to attend the initial orientation session, as well as some of our one hour weekly training sessions, they have chosen not to.

One member of the team is the Union Shop Steward for Table 9. He has been involved from the start and has run hot and cold in his

contribution. to the effort. On the one hand I believe he sees **some** positive outcomes possible from this project, but yet he is very concerned about the possible adverse effects on members he represents from multi-skilling, etc.

If the question were asked - What have we accomplished? I would have to reply "We do not know yet." As far as productivity increases are concerned, it is much too soon to tell. I had indicated some problems had been experienced in late material, rework caused by other shifts, and problems from our Engineering Department.

We are also dealing with a combination of technical and social changes in this area, in that not only have we introduced the team concept into the production process, but we have also begun constructing units in this area in a manner different than that attempted before. Sorting out the effects of these dual changes will be difficult to do. We intend to monitor activity in this area to determine how far up the learning curve we are able to travel, and we hope that once we have additional experience in the area, substantial productivity improvements will have taken place.

Employee attitudes are another area where we hope. to measure some improvement. Although there has been some rocky areas in the team's development, for the most all individuals have been positive and have expressed a willingness to give it a go. Team members seem interested in information about the work they are doing and how it is done, as well as how it fits with the rest of the organization. There has been good participation to date in our meetings and with each meeting the results seem-to be more positive than the last. At one point

a question existed as to whether or not employees had to stay on the team if they were not interested in doing so. At that point an option was granted to the employees if they wanted to leave the team they could, and out of 20 members only two chose to go back to their previous work area.

Vu Graph #7. Again, I would emphasize that the team is very much in the beginning stages of its operation and we have much yet to learn. If I were to pass on those things we have learned already, I would emphasize three in particular. The first is that everyone must be clear on the ground rules, game plan, and objectives of l any reorganization of the type just described. People's expectations have a habit of getting raised beyond what they should be and if the ground rules, game plan, and objectives are not very clear a good deal of resentment can be the result.

Secondly, do not expect results over night. The development of a smooth working team takes a good deal of investment in time and effort. When individuals have never been given a say in their work are asked t o suddenly participate, be prepared to have discussion on lockers, incentives, and a host of other things that may be bugging them before "they will. be willing to invest effort in improving production efficiency.

Thirdly, I would recommend the use of volunteers in any project of this type. It is difficult enough to attempt change in an organization with everything on your side. The task should not be made more difficult by beginning with individuals with little or no interest

in what you are trying to do. Use of volunteers assures you of a willing group to work with, with some interest in the outcome of the project.

We are looking forward to watching the development of this team and participating in it. If we, as a Company, are able to follow through on the commitments that we have made to make the team work, I am confident that employees who are the heart of this team will do their part to make it a success as well.

JS/j
$22
9-24-85

THE SPARROWS POINT YARD/LOCAL 33 EMPLOYEE INVOLVEMENT EFFORT

Presented By

R. David Case
Negotiator, Local 33,
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Stephen F. Sullivan
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Sparrows Point Yard

ABSTRACT

Stephen Sullivan, Bethlehem Steel Corporation and David Case, Industrial Union of Marine Shipbuilding Workers of America, Local 33, Bethlehem Steel Corporation, Sparrows Point Yard

Employee involvement structures in this country, in any industry, are still in the developmental stage, not having achieved nearly the degree of uniformity as their counterparts in Japan and Europe.

This paper will describe the conditions which stimulated consideration of an employee involvement program, the development of groundrules for its operation, the process of orientation and training which preceeded its introduction, successes and failures in its operation, and projections for its role in the future of the Sparrows Point Yard.

The *story* of the Employee Involvement Effort at the Sparrows Point Yard is one that cannot accurately be told in acuum, but must instead be conveyed against the background of the commercial hope and despair and the legal distractions which it has had to withstand and which it continues to have to withstand, to achieve and to maintain the healthy condition which we believe that it enjoys today.

Our presentation will therefore be an attempt to interweave the development of the Employee Involvement Effort, which David will narrate, with the environment within which that development has taken place, which I will periodically interject.

I will begin with a brief profile of the Sparrows Point Yard as it existed at our point of departure in 1981. Located on the Patapsco River just outside of Baltimore, we have been in the business since 1916 of constructing, converting, and repairing commercial and military vessels and, more recently, constructing offshore drilling structures. We have a history since the early 1940's of collective bargaining with the Industrial Union of Marine and Shipbuilding Workers of America, AFL-CIO, ("IUMSWA") and its Local 33.

As we entered into labor agrement negotiations in 1981, Sparrows Point was one of four Bethlehem yards on the East Coast. (The others were the repair yards at East Boston, Hoboken, and Key Highway in Baltimore.) &ch of the four yards was represented by a separate local of IUMSWA. It ~2s traditional that Bethlehem and IUMSWA, with its locals, would negotiate an East Coast agreement covering all of the yards, and the 1981 negotiations did not depart from that tradition.

At the time of those negotiations, the Sparrows Point Yard employed 2,929 people.

The notion of Employee Involvement was introduced by the company during those 1981 negotiations, although, quite candidly, neither party at the bargaining table knew very much about it. Bethlehem as a matter of corporate policy had endorsed the underlying concept of participative management/quality of worklife efforts, 2nd **it** was corporate representatives who presented it to and urged it upon both the union and the yard management representatives. I think it fair to say that, while both sides explored the idea to the extent of satisfying themselves that it **was** essentially harmless, neither side at that point embraced it with unbridled enthusiasm.

In any event, what emerged from those negotiations was an agreement to which was appended enabling language for the conduct of an Experimental Employee Involvement Effort. The language set forth in very broad terms **the** organizational framework to support the building of the effort, but was for the most part replete with philosophic21 musings, which I will quote in part:

> The strength and effectiveness of an industrial enterprise in a democratic society require a cooperative effort between labor and management at several levels of interaction. The parties hereto recognize that if Bethlehem's East Coast Shipyard employees are to continue among the best compensated shipyard employees in the world and if Bethlehem's East Coast Shipyards are to meet domestic and international competition, the parties must pursue their joint objectives with renewed dedication, initiative and cooperation.
>
> Collective bargaining has proven to be a successful instrument in achieving common **goals** and objectives in the employment relationship between Bethlehem's East Coast Shipyard labor and management. However, there are problems of a continuing nature at the level of the work site which significantly impact that relationship, Solutions to these problems are vita1 if the quality of work is to be enhanced and the proficiency of the business enterprise to be improved.
>
> The parties recognize that a cooperative approach between employees and supervision at the work site... is essential to the solution of problems affecting them. Many problems at this level are not readily subject to resolution under existing contractual

> programs and practices, but affect the ongoing relationship between labor and management at that level. Joint participation in solving these problems... is an essential ingredient in any effort to improve the effectiveness of the Company's East Coast Shipyards and to provide employees with a measure of involvement adding dignity and worth *to* their *work* life.

Armed with such lofty principles (and little else), and not really sure of what they meant, we came back to the Yard and, after ratification of the agreement, set about the business of trying to translate them into something useful.

Employment at Sparrows Point had declined slightly to 2,908 but, with a dwindling order book, more severe reductions were on the horizon. With prospects appearing even more bleak at the other three yards, however, Sparrows Point was selected as the pilot yard for the experiment. We were at that point about *to* enter the home stretch in our performance of a contract for the construction of five integrated tug-barges and a series of contracts for the construction of offshore drilling rigs - a market which we had only recently succeeded in penetrating. It was becoming increasingly clear that the need for additional work was becoming more *urgent* with each passing day.

As the commercial market for vessel and rig construction virtually disappeared with falling oil prices and the withering away of CDS and Title XI (as it was applied *to* rig construction), the government became, for Sparrows Point as for so many other domestic yards, the only potential customer. It was at this point that the Sparrows Point management and the officers of Local 33 began a partnership in a lobbying effort among the members of the Naryland delegation in nearby Washington to secure for the Yard and its employees a share of the limited amount of work which was to be available.

It would perhaps suit our present purposes to attribute this partnership to a spirit of cooperation engendered by the Employee Involvement Effort, but it would be inaccurate to do so. The E.I. Effort was as yet in its infancy and had engendered very little other than confusion. It would be accurate in my judgment, however, to credit this uniting for a common purpose with helping to create an atmosphere, at least among the officers of the Local if not the membership in general, which fostered the successful launching of the E.I. Effort.

The launching of the E.I. Effort began with our retaining an outside consultant to act both as an advisor and as a neutral facilitator. In retrospect, it is a certainty that, without the guidance and intervention of an outsider, the Effort would have died aborning.

Our next step, taken in September of 1981, was the establishment of a joint Union/Management steering committee, with the Union members appointed unilaterally by the Union and an equal number of Management representatives appointed unilaterally by the Management. The Local chose to appoint its officers and negotiators; the Management chose *to* appoint a cross-section of representatives, including the General Manager, the Human Resources Manager, and representatives from several levels of Production Management.

After a brief period of treading water, the Steering Committee agreed that there was a need for co-coordinators, *to* facilitate the Committee's meetings and to function as the Committee's liaisons to the Teams as they became established. In November, one such co-coordinator was appointed by the Local and one by the Management.

Before the end of November, several additional steps were taken. Individual interviews were conducted with a randomly-selected cross section

of Yard employees (49 bargaining unit members and 26 Management employees) to evaluate the readiness of the Yard for the establishment of E.I. Teams. A newsletter was distributed to all employees reporting what had been done to date and what was planned. A videotaped briefing, with an in-depth explanation of what the E.I. Effort was all about, was shown to all employees, who were then encouraged to submit to the Steering Committee any unanswered questions.

During December, while the co-coordinators attended a coordinator training program conducted by the American Productivity Center, the Steering Committee continued to meet and to formulate answers to the questions which had been submitted by employees after the videotaped briefing. The answers to those questions were published in a flier which was distributed to all employees.

The E.I. Effort thus enjoyed some momentum as it entered the New Year, but much remained to be accomplished, particularly within the Steering Committee itself. It was painfully obvious in the Committee's meetings that substantial barriers still existed on both sides of the table -- that, in fact, there still were two sides of the table - and that the exchange of ideas and opinions was something less than free.

As the Yard and its employees entered the New Year, the momentum was all in the wrong direction. Layoffs had decreased the workforce to 1,858 -- a reduction of more than 1,000 in 5 months - and manpower projections 'foretold an even more dramatic downturn around the corner. Despite accelerated marketing and joint lobbying endeavors, the market offered little or no cause for optimism on our part.

The Steering Committee had been discussing for some time the consultant's recommendation that it conduct a comprehensive planning session at a location away from the Yard, and that session was finally held in January. For three days, the Committee members lived-in at the Masters, Mates, & Pilots' Maritime Institute of Technology & Graduate Studies in Linthicum, Maryland. From this intense session emerged not only the detailed planning for the establishment and functioning of the E.I. Teams, but also a new sense of trust and open communications among Committee members which has endured to date.

After returning to the Yard, Committee members met jointly with all employees to report to them the products of the offsite planning session. Those reports were supplemented by a flier distributed to all employees.

Approximately two weeks later, a subgroup of Steering Committee (now renamed "E. I. Committee") members visited the Philadelphia Naval Yard to study the operation of its Quality Circles Program.

Finally, in April, the selection from among volunteers of the E.I. Team members was conducted.

As had been agreed upon at the offsite planning session, three multi-craft E.I. Teams were established, each representing *a* different work location: the Ground Assembly, the,Wet Dock, and the Build&g Basin. The members of each Team attended a three-day training session conducted by the co-coordinators and, at the close of the training session, each Team selected two co-chairmen (one Union and one Management.) The Team co-chairmen then attended an additional one-day training session, **also** conducted by the co-coordinators. After all of the painstaking preparation, the Teams were finally a reality and were ready to roll.

The Yard's employment level, unfortunately, was rolling downhill at an unprecedented rate: to 1,491 in April and, in August, to 644, the lowest point in our 66-year history. Indeed, of that 644, only 306 were bargaining unit employees. Layoffs, of course, have long been a fact of life in the shipbuilding industry (although less so in new construction than in repair), and Sparrows Point's employees have seen their share. What was ominously different about these layoffs, however, was that they saw employees with more than thirty years of service leaving the Yard and not knowing if they would ever be recalled. To say that this situation distracted people's attention from the E.1, Effort would be to understate the obvious.

In late August, however, came the announcement of the award to Sparrows Point of a contract for the conversion of three Maersk Line vessels to T-AKX Maritime Prepositioning Ships for the Military Sealift Command, and with that contract award came a new lease on life for the Yard. A significant aspect of the MaersklSparrows Point bid, incidentally, was a Union/Management agreement to extend the no-strike/nu-lockout provision of the labor agreement beyond the fixed expiration date of the agreement to the completion of work on the T-AKX contract.

The three E.1. Teams began to function and, as time passed, began increasingly to struggle. To the obvious problem of losing members to layoffs **was** added the extreme difficulty, which in retrospect we should have been able to anticipate, of trying to achieve any degree of central focus or consensus from among six or seven different crafts, each with its own problems, preferences, and priorities. Even after members had begun to be recalled from layoff, it was still evident that the Committee had aimed

too high in trying to cut its teeth on multi-craft Teams, that the Team members themselves were becoming frustrated, and that the credibility of the E-1. Effort might well be imperiled.

Finally and, perhaps, belatedly, the Committee acknowledged its error and dissolved the three multi-craft Teams in February, 1983. After much careful consideration, the Committee proceeded to create three new Teams: a Welding Team, 2 Shipfitting Team, and a Panel Shop Team. Just as with the previous Teams, the members were trained, they selected their co-chairmen, and the co-chairmen were trained.

As the new Teams began to meet and to function, things began to fall somewhat neatly into place, and their experience has been as gratifying as that of the earlier Teams was exasperating. After a tentative start characterized by a wariness of tackling a problem of significant magnitude, they have matured to the point where the problems which they select become increasingly "bigger" and "tougher". Their success was such that, in . response to growing pressure from other groups, the Committee established three new Teams in September of 1983: a Sheet Metal Shop Team, a Serrice Dept. Team, and a Pipe Shop Team. By the end of 1983, all six Teams were functioning enthusiastically and were more than paying for themselves, even by traditional measures and without regard for increased morale.

In January, 1984, the night shift employees sent a very clear message that they felt that they were being accorded second-class treatment because they had no E.I. Teams. The ensuing exchange produced two more Teams: a 2nd Shift Welding Team and 2 2nd Shift Shipfitting Team. Once trained and set loose, they have prospered just as their daylight counterparts have.

I have sat by without interrupting while David has covered almost three years because I didn't know quite how or where to interject the rest of the background, so I'll try to do it here by just outlining the highlights.

In late 1983, with work on the T-AKX contract at its peak, with no other work on the order books, and with a commercial construction contract scheduled to be bid for which competition promised to be fierce, we approached the Union and proposed that we open early negotiations for a new labor agreement to replace the currently effective one that was not scheduled to expire until August 19, 1984. The Local's negotiators agreed to meet with us to listen to what we had to say. (Since the 1981 agreement was negotiated, the East Boston, Hoboken, and Key Highway Yards had all been permanently shut down, which left Sparrows Point as the onlv surviving yard covered by that agreement.)

We met with the Local's negotiators. We showed them a videotape which set forth the reasons why we felt it imperative that we reduce our employment costs. We then showed the same videotape to all employees. The General Manager and I then held meetings with all employees to answer their questions.

We continued to meet with the negotiators for the next several months. Those meetings culminated in a tentative agreement. The tentative agreement was ratified by vote of the membership on April 1, and was implemented that day.

In the immediate aftermath of the membership ratification vote, the National Union began efforts to set aside the new agreement, to remove the officers who negotiated it, and to place the Local in trusteeship. Those efforts were stymied by a Federal District Court injunction which has

continued to remain in effect. The legal contention and maneuvering has continued unabated for the last year and a half, and the end of it all is not yet clearly in sight.

That the Employee Involvement Effort has continued to progress in the face of this distraction, in particular, is a strong testament to its perceived niche in everyday life at the Yard, despite its relatively brief tenancy there.

Indeed, even after this short experience with it, it would be difficult to envision doing business without it.

PANEL SP-6

MARINE INDUSTRY STANDARDS

J.R. Phillips
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Chairman

ABSTRACT

SNAME Panel SP-6 on Marine Industry Standards is one of ten technical panels operating under the SNAHE Ship Production Committee. Priority shipbuilding research. and development standardization projects are funded jointly by the Maritime Administration,-the U.S. Navy, and the maritime industry. Projects which focus upon the publication and implementation of national standards are coordinated closely with Committee F-25 on Shipbuilding of the American Society for Testing and Materials. The results of these standardization projects have marine industry-wide applications that result in direct cost and time saving benefits in the construction and repair of Naval and commercial vessels.

Panel SP-6, in conjunction with ASTM Committee F-25, together form the National Shipbuilding Standards Program and provide a mechanism to support the Navy's 600-ship fleet. The U.S. Navy continues to increase its direct participation in this program, which has the potential to improve productivity in new construction and life-cycle maintenance by substituting commercial standards for the often more costly Military Standards presently cited.

MARINE INDUSTRY STANDARDS

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INTRODUCTION

The idea of standardization is not new to the shipbuilding industry; however, the creation by industry and implementation by government agencies of marine industry consensus standards is a relatively new one. Over the past nine years, SNAME Panel SP-6 has provided the voluntary efforts of ASTM Committee F-25 on Shipbuilding Standards with over 100 draft standards through a cooperative effort known as the National Shipbuilding Standards Program, This cooperative effort is increasing awareness of the significance of shipbuilding standards that satisfy the needs of Naval and commercial construction. The U.S. Navy and U.S. Coast Guard have been major contributors to the National Shipbuilding Standards Program since its inception, and with this continued support, the Program can continue to develop quality commercial standards for virtually all types of ship building and repair. Standardization has always been supported by upper management, as evidence by the following statement in a recent issue of American Metals Market by Mr. Eddy G. Nicholson, Chairman, Bath Iron Works Corporation,

"Increased standardization of components and whole ships is essential for developing economies of scale and mass production, and can be achieved without degrading mission capability. Both the Navy and the shipbuilders must eschew the traditional "one of a kind" mentality. Development of weapons and electronic systems should focus on making these systems compatible with a variety of ships. In addition, shipyards with Navy concurrence must go much further toward standardizing basic mechanical and structural components which will reduce elapsed construction time and procurements costs for new ships and their spare parts."[1]

THE REASONS FOR STANDARDIZATION

Although everyone is generally in favor of standardization, the reasons for standards need to be clearly understood before this program can reach its effective goal.

Standardization plays an important part in industrial productivity. The degree to which standards are applied to form, fit, or function depends largely upon the specifics of the industry, the elements of the product being produced, and the processes being employed. In recent years, for example., where advanced techniques have been utilized in shipbuilding for modular unit construction, interfaced material and production control, and zone-oriented production, standardization has been one of the key elements in the success achieved. Standardization can be applied to virtually all equipment, material, design, procurement areas, and even the production processes. It can range from standard threads for nuts and bolts to building multiple copies of complete ships with different missions but with the same hull and machinery, altering only those features unique to the mission. Standardization is

usually thought of in terms of mass production. Shipbuilding per se, however, is not a mass-production industry because of the small number of units. Therefore, standardization in shipbuilding usually applies to something less than a whole ship. Overhauls, particularly for submarines, performed late in the ship's service life are adversely affected by the unavailability of parts for critical components. The situation is made more difficult because ships of the same class from different builders have had different suppliers, and therefore different equipment, for similar functions. During the life of a ship, substantial economies can be realized from reduced procurement costs, engineering requirements, and simplification of overhauls, provided attention is given to standardization during design and construction. Logically, the use of appropriate standards will contribute to productivity by assuring required product quality, reducing procurement and production time, and minimizing cost. Standards, if adhered to and maintained, can assure increased service performance, decreased failure, and reduced ship maintenance. Standards assure ease of fabrication, fit, 'quality, and inspection.[2]

Quality involves making something right the first time and involves a tough commitment from the workers to top management to make it work. Building quality into standards and the subsequent products does not come without cost. But one must consider that as quality rises, so does productivity. Consider the impact on productivity if every employee and every machine performed properly

the first time, every time. Employees could then handle more work, inspection could be reduced and those efforts directed towards production, and rework would be eliminated.[3]

Through the extensive use of shipbuilding standards, U.S. shipyards have the potential to sharply reduce construction costs and times through reduction of poor communications and misunderstandings. While reducing cost is the major benefit of standards implementation, other advantages also exist. The customer and builder will be better able to define, agree upon, and meet safety requirements. Standardization also leads to the development of specialized manufacturing of standard components and enables the purchase of these components in larger quantities, with shorter lead times, and at a lower cost. Standards also enable the shipbuilders and manufacturers to level-load their work by assigning the workforce to manufacture and/or construct components during the slack time of a construction program. This can help avoid the layoff-overtime pendulum which often drives qualified workers from this industry.

OVERVIEW OF SNAME PANEL SP-6 ON MARINE INDUSTRY STANDARDS

Since its reactivation in 1977, SNAME Panel SP-6, through MarAd/Navy/Industry cost-shared programs, has performed an essential support function by accomplishing a "pump-priming" effort by providing an initial boost to the voluntary efforts of ASTM Committee F-25 in the form of draft standards. These draft standards are put through the rigorous ASTM voluntary consensus system and eventually published as national shipbuilding standards.

Because of the urgent need for these draft standards to be published, Panel SP-6 has redirected its major effort from a producer of draft standards to assisting in all efforts that lead to publication through the funding of this formerly voluntary effort. Although the panel has redirected its major effort, it will still support the development of high priority shipbuilding draft standards. Recent SP-6 projects and the draft standards produced under them are listed in Table I.

NAVY STANDARDS

By the Navy's own admission, at least 35% of the existing 4,000 MIL-SPECS and 3,500 standard drawings are either out of date or need extensive revisions. This situation is a cause for major concern in light of the current Naval construction program. The Standards and Specifications group within the Naval Sea Systems Command has been participating for two years in a pilot effort to convert Navy Documents into technically up-to-date and less costly commercial equivalents. This work is directed by a subcommittee under the ASTM Committee *F-25* on Shipbuilding. Certain valuable specifications once used by the Maritime Administration have also been introduced into the system. This voluntary program has recently been expanded through funding from SNAME Panel SP-6.

Panel SP-6 has approved a method that will provide direct funding to support the technical review and analysis of selected high priority Navy documents, and this funded program will concentrate on Navy documents which will have the greatest impact within the existing Navy shipbuilding programs when issued as commercial standards. Funding of these selected high priority Navy documents will proceed in parallel with existing ongoing voluntary efforts.

The major benefit of this program will be the cost savings which result from having a base of U.S. shipbuilding standards that will be adopted and cited by the U.S. Navy for use in new construction, repair, or overhaul, This will then reduce the number of military specifications cited in construction of Naval vessels, and allow U.S. shipbuilders the opportunity to use these lower cost commercial standards. The adoption of industry-wide standards will also decrease the effort in the detailed proposal phase of the shipyard/ship owner (Navy) negotiations and yet still have design flexibility that would allow the customer and builder to be able to more easily define the cost elements associated with any unique qualities in the design. The adoption of these standards can only be done by the full participation of government agencies in voluntary consensus standards activities.'

ADOPTION OF INDUSTRY STANDARDS BY THE U.S. GOVERNMENT

For about 25 years, the Department of Defense's (DoD) policy has been to adopt and use nongovernment standarads where they meet needs, rather than duplicate work that has already,been done. In 1976, the Office of Management and Budget (OMB), acting on the recommendation of the Interagency Committee on Standards Policy, began work to issue a government-wide policy similar to the DoD's. That policy was issued in 1982, and provided renewed emphasis for this program, whereby DoD participates in the development work of nongovernment standards groups and adopts their standards where possible.

Government participation in standards development is generally for the purpose of ensuring that its requirements are given consideration in drafting the standard. For representation to be effective, the government must begin in the early drafting stages of the nongovernment standard and be consistent throughout development. When appropriate, and if the ASTM committee agrees, Navy, Coast Guard, and other government groups needs can be accommodated in the document by inclusion, reference, or other suitable means. Government participants must not attempt to "militarize[tl]" nongovernment documents through inclusion of unique requirements best left to military documentation. Often government's needs apply to other users as well and inclusion of a "when specified" paragraph which can accommodate those users without adversely affecting other use of the document. This makes the standard more easily adoptable by the Navy and many others who use the documents for procurement.

It is DoD policy that, where a nongovernment standard exists, or can be prepared in time to meet the DoD's needs, it will be adopted in lieu of preparing or maintaining an equivalent military specification or standard. Adoption is the process by which DoD examines a nongovernment document and formally accepts the document. The adopted document is then listed in the DoD Index of Specifications and Standards (DODISS), and is the only version of the standard authorized for use by DOD. Any further revision to the document must be reviewed and adopted on its own merits. Documents which fully satisfy the needs of, the Navy and other government groups with respect to technical sufficiency and economy are generally adopted.

Some problems exist within the present system, as was recently pointed out by DoD official Gregory Saunders.

"Government specification writers have a somewhat natural bias toward their own documents. They know intimately the system under which they are prepared and the procedures for making changes. Although the military specification system is a near consensus operation, the preparing activity (that group or agency that initiates a standards action) has a certain degree of latitude in considering and overruling comments and can get a document issued very quickly when necessary. Some preparers resent replacement of documents, on which they have spent a great deal of effort, with nongovernment documents, which they sometimes feel represent lowest common denominator standards. And even where document preparers do want to participate, adopt, and use nongovernment documents, they encounter difficulties getting commitment from upper management for travel necessary for consistent participation.

The mere existence of a policy to utilize nongovernment standards does not guarantee compliance within DoD any more than it does in any other organization. It takes time to overcome the prejudices against nongovernment standards, but progress is being made. Many DoD document preparing activities make extensive use of nongovernment standards and are showing that the myth of lowest common denominator is largely just that: a myth. It is being demonstrated on a daily basis that the benefits of participating, adopting, and using nongovernment standards far outweigh the disadvantages. This is an educational problem within DoD that can be resolved most readily through continued positive examples."[4]

RESULTS OF ASTM COMMITTEE F-25 ON SHIPBUILDING STANDARDS

All of the previously mentioned organizations are significant in the standardization process, but the most critical role is played by ASTM and its consensus process.

Draft standards resulting from SNAME Panel SP-6 projects are submitted to ASTM Committee F-25 for processing through this consensus system. ASTM's nationally recognized consensus standards have a built-in mechanism for periodic maintenance via a mandatory five-year minimum review cycle. This is an important element in keeping each standard current with existing technology.

The economic benefits of standardization are known to all of us; however, it is the entire industry's responsibility to produce the needed standards. No single organization can accomplish a task of this magnitude alone. The cooperative government/industry program underway within SNAME SP-6/ASTM F-25 provides a suitable mechanism to accomplish the task. What remains to be achieved is to secure the industry's full commitment to do the job.

The efforts of ASTM members are voluntary, and place the burden of standards development upon individual industries. The steel and automotive industries, for example, have developed their standards activities over many years. In these industries, active participation in organizations like ASTM is considered essential business practice, without which business activity would most certainly be chaotic.

ASTM Committee F-25 presently consists of technical subcommittees, each one concentrates on an individual area of shipbuilding standards development;

To date, over 30 standards have been published and several more standards are undergoing the final stages of the ASTM consensus process previous to publication. Presently there are over 125 active standards projects in various stages of development, and with SP-6 funding, many standards previously delayed in the industry consensus process will soon be published. See Table II for a listing of published F-25 standards.

The U.S. Navy has adopted many of the standards published by ASTM, and is presently reviewing others for suitability in Naval ship construction. As these ASTM standards are cited in Naval construction contracts and also the U.S. Coast Guard Regulations, the economic effects will be fully realized.

The full recognition of the importance of shipbuilding standards is most easily seen when potential dollar savings through the extensive use of these standards is stressed, and all future SP-6 projects will focus strictly on standards that will result in significant cost savings when cited in Naval construction contracts.

As of yet, the U.S. Shipbuilding Industry has not established an across-the-board commitment to standardization in spite of the fact that the term dardlt is being used on an increasing basis by experts of all kinds. Until our industry makes standardization a part of our daily routine, the maximum potential of the ASTM F-25 standardization program cannot be realized.

CONCLUSION

The use of current industry standards represents one of the most significant opportunities for improving productivity and cost reduction in the shipbuilding industry. Standards are also a necessary requirement for the development of automation in the industry.

Increasing the use of commercial shipbuilding standards on both Naval and commercial ships is a primary goal of the National Shipbuilding Standards Program. Again, the ultimate success of the program rests with the industry's ability to provide the resources necessary to support the efforts of both SNAME Panel SP-6 and ASTM Committee F-25. Your active participation assures that this program can continue to develop into the industry focal point for sound industry shipbuilding standards that can be used in both Naval and commercial construction.

REFERENCES

1. Eddy G. Nicholson, "Rebuilding of U.S. Fleet is Vital National Goal," American Metal Market, April 30, 1984.

2. National Research Council Committee on Navy Shipbuilding Technology Marine Board "Productivity Improvements in U.S. Navy Shipbuilding," National Academy Press, June, 1982.

3. Kathleen Riley, "Quality Requires Commitment," Standardization News, July, 1985.

4. Gregory E. Saunders, "Gimme A Spec," Standardization News, May, 1985.

TABLE I-

RECENT DRAFT STANDARDS' & REPORTS

SPONSORED UNDER PANEL SP-6

Task S-25 on HVAC Construction Standards:

- Standard Specification for Goosenecks
- Standard Specification for Terminals
- Standard Specification for Fire Dampers
- Standard Specification for Control Dampers
- Standard Specification for Duct Hangers
- Standard Specification for W.T./N.W.T. Closures
- Standard Specification for Penetrations
- Standard Practice for HVAC Drafting
- Standard Practice for Volumetric Testing of HVAC Air Systems
- Duct Details

Task S-27A, Outfit Construction Standards:

- Standard Practice for Machinery Space Supports for Machinery Space Floors, for Marine Use
- Standard Practice for Machinery Space Floors for Marine Use
- Standard Specification for Handrails, Open (Storm and Guard)
- Standard Specification for Staples,Handgrabs, Handle, and Stirrup Rungs
- Standard Specification for Semi-Flush O.T./W.T. Bolted Manhole
- Standard Specification for Semi-Flush O.T./W.T. Hinged, Bolted Manhole
- Standard Specification for Raised O.T./W.T. Bolted Manhole
- Standard Specification for Machinery Space Handrails and Stanchions
- Standard Specification for Flush O.T./W.T. Bolted Manhole

Task S-28, Update of MarAd Schedule for Pipes, Joints, Valves, Fittings, and Symbols:

- Standard Material Schedule for Shipboard Pipes, Joints, Valves & Fittings for Commercial Ship,&

Task S-30, Mechanical Construction Standards:

- Standard Practice for Design and Application of Valve Label Plates
- Standard Practice for Arrangement of Piping System Thermometer Connections
- Standard Specification for Expanded Sockets for Pipe & Tubing
- Standard Practice for Design of Overboard Discharge Connections
- Standard Practice for Design of Lifting Padeyes
- Standard Specification for Bilge Strainer Boxes
- Standard Practice for the Selection & Application of Valve Operating Gear

Task S-31, QA/QC Acceptance Standards:

- Study produced list of QA/QC acceptance standards in use and made recommendations to produce priority standards.

Task S-32, Purchase Specification Bid Response Sheets for:

- Tubular Heat Exchangers
- Plate Type Heat Exchangers
- Centrifugal and Rotary Pumps for Liquid Service
- Axial Flow Fans
- Centrifugal Fans
- Control Valves
- Remote Valve Operators
- Packaged Refer Units
- Refer Compressors - Reciprocating
- Refer Compressors - Rotary
- Refrigeration Condensers, Receivers, Accumulators
- Refrigeration Oil Traps & Separators
- Refrigeration Expansion Valves, Gages, Thermometers
- Ship Service Generators
- Emergency Generators

Task S-33, Mechanical Construction Standards IV

- Standard Specification for Fire & Foam Cabinets
- Standard Practice for Selection of Thermometers
- Standard Practice for Selection of Gages for Vacuum, Pressure, and Compound Services
- Standard Practice for Shotblast Descaling of Interior Surfaces of Steel Pipe
- Standard Specification for Rigid and Non-Rigid Reach Rods
- Standard Specification for Large Plate Flanges, 14" O.D. and above
- Standard Specification for Tank Sounding Striker Plates
- Standard Practice for Forming Flanged Pipe/Tube Ends for Lap Joint Flanges (Van Stone)

Task S-34, Feasibility Study for the Commercialization of U.S. Navy GENSPECS:

- Study produced final report for the feasibility of U.S. Navy GENSPECS, identifying Navy Standards that could be substituted with existing commercial standards.

Task S-35: Hull Design & Construction Standards:

- Standard Specification for Three Compartment Dispensing Tank
- Standard Specification for 65 Gallon Dispensing Tank
- Standard Specification for Portable Davits
- Standard Specification for Ships Letters and Numerals
- Standard Spedification for Cargo Tank Ladders
- Standard Specification for Cargo Tank Rails
- Standard Specification for Cargo Tank Platforms
- Standard Specification for Pyrotechnic Storage Box

Task S-36, Functional Design Configuration Standards:

- Functional Configuration Standards showing typical equipment packages for:
  - Multi-Stage Distiller
  - Geared Steam Turbine Lube Oil Unit
  - Fuel Oil Service Unit
  - Service Air Unit

Task S-37, Watertight/Gastightand Non-Weathertight Door Standards:

- Standard Specification for Watertight Door
- Standard Specification for Airtight/Gastight Door
- Standard Specification for Non-Weathertight Door
- Standard Specification for Gastight Double Door
- Standard Specification for Dutch Door

Task S-39, **Functional Design Standards:**

- Expanded Metal Bulkheads
- Expanded Metal Doors
- Jack Staff
- Ensign Staff
- Portable Guard Rails
- Emergency Gear Stowage Locker
- Deck Gear Stowage
- Panama Canal Shelter
- Valve Locking Devices
- Chemical Feed Tanks
- Docking Plugs
- Dog Bolts

Task S-dOA, Standard Bid Response Sheets - Phase II:

- Propulsion Lineshaft Bearings, Lined Pillow-Block Type
- Propulsion Lineshaft Bearings, Rolling-Element Type
- Stern Tube Bearings, Water Lubricated, Stave-Type, Rubber
- Stern Tube Bearings, Water Lubricated, Stave-Type, Other than Rubber
- Stern Tube Bearings, Water Lubricated, Solid-Type, Rubber
- Propulsion Shafting Bulkhead Stuffing Boxes
- Stern Tube Stuffing Boxes
- Fuel Oil Heaters, Diesel/JP=5/0ther "Light" Fuels
- Fuel Oil Coolers, Diesel/JP-S/Other "Light" Fuels
- Fuel Oil Meters, Diesel/JP-S/Other "Light" Fuels
- Fuel Oil Centrifuges/Purifiers, Diesel/JP=5/0ther "Light" Fuels
- Fuel Oil Filters, Diesel/JP-S/Other "Light Fuels

- Fuel Oil Suction Strainers, Diesel/JP-S/Other "Light" Fuels
- Fuel Oil Discharge Strainers, Diesel/JP-5/0ther "Light" Fuels
- Fuel Oil Heaters, Heavy-Oil Fuels
- Fuel Oil Meters, Heavy-Oil Fuels
- Fuel Oil Suction Strainers, Heavy-Oil Fuels
- Fuel Oil Discharge Strainers, Heavy-Oil Fuels
- Lube Oil Coolers (heat exchangers)
- Lube Oil Heaters (supply to machinery)
- Lube Oil Suction Strainers
- Lube Oil Discharge Strainers
- Lube Oil Centrifuges/Purifiers
- Lube Oil Purifier Heater
- Lube Oil Filters
- Stern Tube Bearings, Oil Lubricated
- Propulsion Shafting Thrust Bearings
- Propulsion Shaft Couplings
- Propulsion Shaft Brakes
- Stern Tube Seals
- Strut Seals
- Vacuum Equipment Associated with Steam (Condensing) Systems
- Vacuum Equipment Associated with Distilling Systems
- Vacuum Equipment Associated with Pump Priming Systems
- Vacuum Equipment Associated with Sewage Systems

Task S-41, Standard Practice for Identification and Description of hVAC Configurations:

- Standard Practice for Identification and Description of Design Configurations for Frequently Used Sheetmetal Ventilation Duct-work Shapes

Task S-42, Accelerated Publication of National Shipbuilding Standards:

- o Insulated W.T./O.T. Bulkhead & Deck Penetrations .
- o Steel Flanges for Non-Ferrous Piping
- o Welded Sleeves for W.T./O.T. Bulkhead 6 Deck Penetrations
- o Commercial Steel Air Receivers
- o Commercial Steel Portable Water Tank
- o Butterfly Valve Envelope Dimensions
- o Mechanically Attached Fittings

Task S-43, Cableway Standards:

- o Standard for Cableway Components and Ass,emblies

Task S-44, Deck Covering Guide:

- o Standard Guide for Deck Covering

Task S-45A, Technical Review & Reformatting of the Following Navy Documents:

o Paint Coating System, Steel Ship Tanks, Fuel & S.W. Ballast (Combine with MIL-C-4556)	MIL-P-23236
o Deck Covering in Electrical/Electronic Gear	805–2104467
o Fibrous Double–Braided Polyester Rope	MIL-R-24536
o Acceptable Methods for Fitting Chocks	810-1385895
o Water Trap for Diesel Engines	810-1385887
o Terminals, Air, Diffusing, Circular	MIL-T-11576
o Rope, Nylon	MIL-R-17343
o Paint, Aluminum, Heat Resisting	TT-P-28
o Corrosion-Prevention Compound, Solvent Cutback, Cold Application	MIL-C-16173
o Paint Epoxy Polyamide, General Specification For	MIL-P-2441
o Cleats, Welded Horn Type	NAVSEA Type Dwg. 805-2276338
o Cleats	NAVSEA Type Dwg. S1201-860099
o Fibrous Plaited Polyester Rope	MIL-R-14537
o Rope, Fibrous, Double Braided, Nylon	MIL-R-24050
o Rope and Yarn, Plied, Synthetic Fiber	MIL-R-24050
o Polypropylene Cores, Strand Center and Substrands for Wire Rope	MIL-P-24216A
o Rope, Polyester, Film	MIL-R-24335
o Rope, Nylon, Plaited	MIL-R-24337 .
o Rope, Polyester	MIL-R-30500
o Rope, Fibrous, Plaited, Polyester, Polypropylene Dual Fiber	MIL-R-43952

Task S-45B, Technical Review & Reformatting of the Following Navy Documents:

o Strainers, Steam (3 inches and below)	MIL-S-2953
o Expansion Joint, Pipe, Synthetic Rubber, Fire Retardant (Nav)	MIL-E-15330
o Strainers, Basket Type of SW Service, Assemblies & Details, 100 PSI Max.	S-4823-13855
o Shipboard Flush Valves	MIL-V-15020
o Check Valves for Low Pressure Air, Water and Oil Service	MIL-V-17547
o Spray Shields for Mechanical Joints	803-2145518
o Tubing, Round, Seamless Alloy Steel	MIL-T-15119
o Pipe Support Devices	MIL-P-15877
o Pipe Hangers and Supports	WW-H-171
o Connections, Flexible Shafting	S–4824-841650
o Connections, Flexible Shafting for Remote Valve Operation, Couplings and Quick Disconnect Assemblies	S-4824-841651
o Connections, Flexible Shafting for Remote Valve, Operations. Couplings and Quick Disconnect Assemblies	S–4824-841653
o Hangers, Pipe, for Surface Ships	804-1385781 (4 Dwgs.)
o Deck Plates for Operating Gear and Sounding and Filling Connections	S–4823-86022
o Gratings, Metal, Bar Type Flooring, Naval, Shipboard	MIL-G-18014B
o Gratings, Metal, Other than Bar Type (Shipboard Use)	MIL-G-.18015A

Task S-45C, Technical Review & Reformatting of the Following Navy Documents:

- o Light, Marker, Distress, and Night Replenishment — MIL-L-573
- o Lock, Flush, Metal and Wood Door and Drawer, Naval Shipboard — MIL-L-2898
- o Tank, Pressure, 600 psi Gage Working Pressure, Naval Shipboard Use — MIL-T-15301
- o Reel, Fueling Hose, Manually Operated — MIL-R-15917
- o Reels and Hose Guides, Manually Operated — MIL-R-24414
- o Dehumidifier, Space, Mechanical Refrigeration — MIL-D-19947

Task S-46, Participation on the International Standards Organization's Technical Committee (ISO TC-8) on Marine Standards:

- o The project essentially provides seed money.to the USA Technical Advisory Group (TAG) to participate on ISO TC-8 in the development of international marine standards.

Task S-48, Diesel Engine Standard

- o Standard for Main Propulsion Medium Speed Diesel Engine Performance and Minimum Scope of Assembly

Task S-49, Shaft Alignment Standard

- o Standard Practice for the Alignment of Propulsion Shafting Systems Using the Strain Gage Method

Task S-50, Marine Window Standards

- o Fixed Windows
- o Horizontal Hinged Windows
- o Heated Windows
- o Sliding Windows
- o Pendulum Window Wipers

Task S-51, Development of Portlights Standards

- o Portlights Standards

TABLE I I

PUBLISHED ASTM COMMITTEE F-25 Standards

F-670-80	Specification, Five Gallon (20 liter) and 10 Gallon (40 liter) Dispensing Tanks
F-681-82	Practice for Use of Branch Connections
F-682-82a	Specification for Wrought Carbon Steel Sleeve Type Pipe Couplings
F-683-84	Practice for Selection and Application of Thermal Insulation for Piping and Machinery
F-704-81	Practice for Selection of Bolting Lengths for Piping System Flanged Joints
F-707-82	Specifications for Modular Gage Boards
F-708-81	Practice for Design and Installation of Rigid Pipe Hangers
F-718-85	Shipbuilders and Marine Paints and Coatings Products/Procedures Data Sheet
F-721-81	Specification for Gage Piping Assemblies
F-722-82	Specificaiton for Weld Joint Design for Shipboard Piping System
F-765-82	Specification for Wildcats, Ship Anchor Chain
F-782-82	Specification for Doors, Furniture, Marine
F-783-82	Specification for Staple, Handgrab, Handle, & Stirrup Rungs
F-821-83	Specification for Door and Frames, Steel, Interior, Marine
F-822-83	Specification for Chest of Drawers (Chiffonier), Marine
F-823-83	Specification for Desk, Log, Marine, with Cabinet
F-824-83	Specification for Tables, Mess, Marine
F-825-83	Specification for Drawers, Furniture, Marine
F-826-83	Specification for Tops, Furniture, Marine
F-840-83	Specification for Ladders, Fixed, Vertical, Steel Ships'
F-841-84	Specification for Thrusters, Tunnel, permanently Installed in Marine Vessels
F-856-83	Practice for Using Symbols of Heating, Ventilation. and Air Conditioning (HVAC) Systems
F-885-84	Specification for Envelope Dimensions for Bronze Globe Valves NPS 1/4 to 2
F-906-84	Practice for Ships Letters and Numerals
F-915-85	Specification for Bitts, Ship Mooring, Cast Steel
F-916-85	Specification for Elevators, Shipboard, Electro-mechanical, Passenger, and Stores
F-936-85	Specification for Chocks, Panama, Mooring, Cast Steel
F-937-85	Specification for Chocks, Ship Mooring, Cast Steel
F-938-85	Specification for Bitts, Ship Mooring, Welded Steel (Double Barrel)
F-940-85	Practice for Quality Control Receipt Inspection Procedures for Protective Coatings (Paint) Materials Used in Marine Construction and Shipbuilding
F-941-85	Practice for Inspection of Marine Surface Preparation and Coating Application
F-957-85	Specification for Gongs, Sound Signaling

STANDARDIZATION
FROM
MARINE EQUIPMENT SUPPLIERS PERSPECTIVE

PREPARED FOR PRESENTATION AT THE
NATIONAL SHIPBUILDING RESEARCH PROGRAM (NSRP)
ANNUAL TECHNICAL SYMPOSIUM
. SEPTEMBER 11-13, 1985
LONG BEACH, CALIFORNIA

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ABSTRACT

The deep depression of the shipbuilding industry in the United States has brought into sharp focus the fact that broad and sweeping changes must be rapidly implemented if the industry is to survive. The factors leading to the decline of U. S. shipbuilding are many and complex and there are no quick and easy solutions. However, it must be recognized that many of our traditional manufacturing procedures and techniques are prominent among those factors. Although some of the industry's problems may be outside the influence of technical societies, manufacturing procedures and methods are not, and are, in fact, already being dealt with through the Society's participation in the National Shipbuilding Standards program. The task is not easy, however, since there has been considerable indifference, if not outright resistance, to standardization by marine equipment suppliers, particularly deck machinery manufacturers.

INTRODUCTION

Precedents

The idea of standards is not new. Throughout recorded history, many cultures and societies have implemented various standards in order to establish some basis or benchmark by which fair, equitable and consistent practices could be assured in Commerce. and industrY. In the ASTM publication "The What and Why of Standards", (1) an Old Testament passage is cited as one of the earliest standards when God told Noah "Make thee an ark of Gopher wood; rooms shalt thou make in the Ark, and shall pitch it within and without with pitch" (Genesis 6:14). Coincidentally, it should be noted that this was probably the first shipbuilding standard!

Although the idea of standards has its roots deep into antiquity, the creation and implementation of industrial and voluntary concensus standards is relatively new. Previous standards, such as the Biblical one noted above were imposed without choice by a higher authority. A classic example of this is seen in the establishment of a standard railroad gauge in the 19th Century to permit the rapid transfer of railway cars with their passengers and cargo from one rail line to another. Without this standard, the development of the great American west would have been seriously impeded and the exchange goods and products across the nation would have been extremely difficult.

By the mid-19th Century, as the Industrial Revolution began to gain momentum, the need for standardization began to be realized. Significantly, this impetus was not based on government or authorative edicts, but from leaders within industry itself who saw the creation of standards as being in their own best interest, as well as for the general welfare and public good. Gradually, as representatives of various industrial segments began to join efforts, the foundations were laid for many standardization societies with which we have become quite familiar. Early among them were the American Society for Testing and Materials (ASTM) the American Gear Manufacturing Association (AGMA) followed by others, such as the National Electrical Manufacturers Association (NEMA), National Fluid Power Association (NAPFA), the American Welding Society (AILS) to name a few. With the emergence of so many standards writing groups, duplications and contradictions were inevitable. In an attempt to help counter some of these problems, the American National Standards Institute (ANSI) was formed to coordinate the writing of standards. In more recent times, as new technologies and discoveries appeared, the writing of standards and their implementation have proliferated and will, doubtless, continue to do SO.

Standards and Shipbuilding

Although the United States shipbuilding industry benefited greatly from standardization by other agencies, it is ironic that the industry had no standards for the production of its own products. In fact, there appeared to be little or no interest in standards development until the 1970's when, through the efforts of both government and the industry, the National Shipbuilding Standards Program evolved. This was followed a year later by the activation of the SNAME Panel, SP-6 and in 1978 the ASTM Comnittee, F-25 on Shipbuilding was formed. (This Committee, comprised of hundreds of volunteers from every segment of the shipbuilding industry, is currently engaged in a vigorous effor to draft comprehensive and concise standards for shipbuilding. Their efforts are supported by active cooperation and encouragement from many other agencies, including SNAME, MARAD, the Navy and other standarding groups.

The task is slow and arduous and we are, perhaps, yet years away from a complete set of workable and meaningful standards. To make the picture even gloomier, the United States, once the most productive shipbuilding nation in the world, has become at best a third rate producer. In fact, the production of ocean going merchant vessels in the United States is at a virtual standstill.

The Worth of Standards

It would be naive to suggest that the lack of standards alone led to the demise of our industry. There are many other complex and far reaching factors which contributed to the decline. However, the absence of clearly defined standards for manufacture, construction, methods, and materials created a virtual technical Babel of Confusion with no real means to stimulate the exchange of ideas or create joint

counter measures. The consequence was that even while we were losing, we knew we were losing, but most of us did not know why.

STANDARDS AND THE MARINE EQUIPMENT SUPPLIER

Resistance

Typically, the average U.S. supplier of marine equipment has been thoroughly American; independent, confident, secretive, arrogant, competitive, jealous, ingenious and reliable. Nurtured in the culture of the world's greatest system of free enterprise, he came to regard anything American made as being the best in the world and his particular product as being the best of the best. And, although he was not above "copping" the ideas of his rivals when it suited his best interests, he would have been horrified at the idea of free exchange of ideas and tended to view the concept of standardization as an encroachment on his right to creative and innovative thinking. And yet, there were standards of a sort. They were the standards of custom, tradition and the unwritten concept of "the right way to do things". For many decades, these concepts not only prevailed, but also worked; and, as a matter of fact, did result in some of the world's finest products. During the challenging days of World War II, another set of standards were gradually developed, as the best minds in the industry and Navy worked together to further formulate and refine Navy standards and specifications which, for the most part, became the industry standard for all marine equipment. These were largely carried over into the commercial field even after the war. Needless to say, equipment designed and built to the severe requirements of military use were unsurpassed for quality, datability and reliability. They were also unsurpassed for price.

Complacency and Shock

Subsequent to World War II, marine equipment suppliers, confident in the excellence of their products did little to address changing conditions, but continued to rely on what they believed to be the optimum. Although some new ideas were advanced, they were largely rejected by builders and users alike. Early on, when U. S. suppliers began to lose some orders to foreign competitors, there seemed to be undue excitement. The general attitude toward the foreign made equipment was quite often expressed as “cheap”, “junk”, “it won’t last”, or “you can’t compete with fifty cent labor”. It was not unlike the attitude of the U. S. automobile industry who, convinced Americans would never give Up their big gas guzzlers, saw the Volkswagen as a novelty and a fad until one day they were shocked and awakened to the fact that Toyotas, Datsuns and Mazdas were dotting the entire American landscape. The marine equipment people were in for some surprises too. As the trickle of foreign equipment became a stream and then a torrent, we came to realize that their products were inexpensive, but not “cheap different, but not “junk”; they did last; and, although built by workers at a lower wage, had been designed economically to an entirely different set of standards. We could take some bittersweet comfort in believing our products to be better, but we could not say theirs were inadequate. The tragic fact is, we were trying to play the same ball game to a different set of rules.

WHERE ARE WE TODAY - OR WHY STANDARDS?

We, who are in the marine equipment business, must face the fact that the day of the backyard inventor is over. The world is too technologically advanced, too complex and too competitive for any man or group of men to survive alone. There must be some meeting of minds; some exchange of ideas whereby we can outline some basic parameters

to foster the acceptance and use of our equipment. For our industry to survive, the U.S. shipbuilding industry must survive. For the shipbuilder to survive, he must find new and better ways to increase productivity, reduce costs and improve deliveries. While much of this is incumbent on the shipbuilder himself, there is much that can be done by the marine equipment manufacturer to assist him in this formidable task. Perhaps, one of the best ways to accomplish this goal is for the shipbuilder, supplier and user to formulate and implement specific, concise and usable standards.

Standards for Communication

Historically, one of the biggest problems for the shipbuilder and the equipment supplier has been a problem of communication. Too often, the equipment delivered to the shipbuilder bears very little resemblance to what the purchaser had in mind. The reason is quite simple. Communication between the purchaser and supplier has been inadequate and confusing. The net result has been added costs and delays. It has also created a way for the unscrupulous entrepreneur to undercut legitimate suppliers-and walk away with all the marbles at the expense of the shipbuilder. In his paper, “Cost Reduction in Deck Machinery”, Mr. Don Pettit says, “the terminology of deck machinery is a mixture of seagoing terms from antiquity and master mechanics or engineering terms from many fields. One of the earliest pay-off’s from the National Shipbuilders Standards and Specification program may be in the area of standardized terminology and ordering information".(3) A well written standard can delineate clearly and concisely the different types and grades of equipment plus a comprehensive purchasing information check list understandable to purchaser and supplier alike.

Standards for Interfacing

As simple as it may sound, the installation of marine equipment can be one of the most exasperating and expensive problems the ship-builder faces. While even the best written standard cannot identify or establish all interfacing requirements, it can provide for the major ones and call attention to others to prevent overlooking them. "Standards can certainly address foundationing requirements and even provide a means for actually integrating the equipment with the ships structure." (3) Many other" interfacing needs, such as electrical requirements, piping connections, maintenance access, ships service air, cooling water, special tools, lifting provisions, if not actually identified can be called for in the standard. With such information in hand during the production design stages of a ship, many man hours and dollars can be saved when it is time for the installation.

Standards for Design Improvement

One of the strongest and loudest protests against standardization has been that it will stifle design creativity and innovation and that competition will be strictly based on price and price alone. At first glance, this appears to be true; however, a more detailed and objective view would indicate that the exact reverse is the case. Too often, we have striven to make our product unique without making it better. Once basic design parameters are established, the designer is then face with more critical and meaningful problems, such as performance quality cost effectiveness, improved designs, more efficient manufacturing procedures, reliability, better materials and material selection, lower maintenance, better quality, and better user acceptability. A classic example of this can be cited. The National Electrical Manufacturers Association (NEMA) was founded in 1926 to establish standards for the manufacture of electrical products. Among those standards written,

was the standard for electric motors. This standard established basic physical characteristics with which most of us have become intimately familiar. These characteristics included frame sizes, type, mounting dimensions including bolt sizes and locations, shaft location and dimensions, keyway sizes and several others. Far from creating a technological vacuum, we have seen competitiveness increase as the various manufacturers have worked to achieve better performance, better materials, improved insulations, better bearings, reduced cost and greatly increased reliability; until today most of us recognize the electric motor as one of the most efficient and reliable mechanical devices on earth.

Standards for marine equipment may never be as all encompassing as the standard for electric motors, but it seems reasonable to conclude that better standards will result in better products.

Standards for Standards

Note that this subtitle does not say “Standards for Standards Sake”. The designer of marine equipment is innundated with a myriad of standards covering the entire spectrum of materials, procedures, and methods. Often, he is still researching standards when the design should be half completed. In their paper, “Machinery Standards in the Global Arena” (4), Messrs. Narbut and Ridley approximated that more than 3,000 standards from producers, users and regulators can impact the various segments of marine design. Obviously (and thankfully), not all these standards apply to any one product. The standard for wooden crates will have little interest or information for the designer of a gear set, while the shipping supervisor, who builds wooden crates has little use for the AGMA standard for gear design. Therefore, specific standards for specific equipment can cut through this curtain

of confusion by identifying other standards which apply directly to equipment to be produced; by grouping the standards to specific aspects of the design; and by selecting certain standards to the exclusion of others, thus preventing ambiguities and needless redundancies.

THE ELEMENTS OF A STANDARD

The dictionary defines a standard as "a means of determining what a thing should be". Volumes have already been written on standards as to content, format, scope, etc. , therefore, for the purposes of this discussion, a few basic elements will be considered as being the germ of many other discussions.

Consistency

Consistency within a standard has many facets. Insofar as possible, it should be consistent with general practice, state of the art, actual need, overall goals and existing requirements. It must assure that every competent supplier has equal opportunity and that the shipbuilder can be assured of a quality product regardless as his source.

A young lady queired about her dress size replied, "I take a Saks 8, a Rosenblum 10 and a K-Mart 14". This is not the kind of standard we need. In a recent meeting of the ASTM F25.08 Steering Gear Task Group, there was considerable discussion over the appearance of efficiency factors for various rudder actuators. These factors have been in wide usage for many years and are included in the Military Standard for steering gears. After considerable discussion, it was suggested that the factors be included for guidance, but that other factors supported by calculations or test evidence could be used.

Although the final standard may or may not include these factors, here is an example of how standards must be consistently applicable while permitting new and better approaches.

Flexibility

As seen in the foregoing, standards must permit flexibility. First, there must be flexibility within the standard. In order for a standard to have meaning and value to the shipbuilder and user, we must necessarily have certain peripherical constraints and limitations; however, we must leave sufficient inner space for the creative mind to work and new ideas to fill. Another example is taken from the steering gear world where for many years a limit on hydraulic pressure has been stated in maximum pounds per square inch. This was established at a time when hydraulic components were far less developed than today. If left to stand, where is the incentive to develop better components? Many similar parallels could, no doubt, be drawn. It is essential that we not lock out innovation and creativity.

Specific

The quality of a standard is not based on its length or number of words, but rather on what it actually says. A useful standard clearly states what a thing must be. The vagueness, ambiguities and incompleteness of our previous methods must be eliminated. The standard must be drafted in such a way that both purchaser and supplier clearly understand each other. Type, class grade, performance requirements, envelope sizes, interfacing constraints and all other necessary data must be anticipated and addressed if the standard is to be usable.

Realistic

Standards writing groups must be fully aware of the fact that the U. S. shipbuilding industry has to compete worldwide. To this end,

they must look at the standards of their competitors. The development of standards will be of little value if they impose more stringent requirements than those of other countries. No one wants to undermine the quality and integrity of American products; but if marine equipment suppliers in the United States are compelled by standards to produce a more expansive product than can be acquired elsewhere, then our own shipbuilders and shipowners will continue to buy foreign made equipment.

Conclusion

In conclusion, it must be stressed that the ultimate value of any standard will be in its utilization. Over the past several years, literally thousands of man hours and dollars have been voluntarily contributed toward the development of meaningful standards - and we have just begun. Many more hours and dollars will be expended before the task is complete. However, all this effort will be in vain if the resultant standards are not used and applied. While there will always be instances where special equipment will be required, this should be the exception rather than the rule. In our highly competitive world, we must avoid situations where the number of pages listing the exceptions to the standard outnumber the pages of the standard itself. Then, and only then, will standards prove their worth.

References:

1. "The What and Why of Standards", ASTM Bulletin "Standardization Basics".
2. William H. Hundley and Thomas M. Hopkins, "The National Shipbuilding Standards Program, It's Effect on the Navy Engineer".
3. Don G. Pettit, "Cost Deduction In Deck Machinery Installation". IREAPS Symposium, August, 1983.
4. Francis L. Narbut, "A Knight's Move, Machinery Standards in the Global Arena", Great Lakes and Great Rivers Section, SNAME, October, 1982.
5. Donald S. Delicat and Thomas P. Mackey, "Marine Industry Standards: A General Discussion with Particular Reference to Pollution Abatement Equipment". Marine Technology, July, 1984.

"MAKING THE RIGHT CONNECTION"

Piping Systems, Past, Present and Future

By

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Metal Components

Abstract

A fundamental concern of members of the shipbuilding community is the escalating cost of repairing and fabricating piping systems. These shipbuilders are searching for ways to reduce installation costs and to improve the quality and timeliness of shipyard output.

The primary cost in attaching segments of a piping system is directly related to installation man-hours for welding or brazing, flushing, hydro-static testing, quality assurance and potential re-work. The more labor intensive the piping installation, the greater the need for an alternative method.

New technologies have provided more cost effective methods for permanently joining piping. One viable alternative is the Swage Marine Fitting.

Swage Marine Fittings (SMF) are mechanically applied connections that significantly reduce installation man-hours by eliminating hot-work and conventional N.D.T.

This paper will discuss the history of welding and brazing, the development of mechanically applied pipe connections and the potential impact that this technology will have on the future of piping fabrication and repair.

The topic of this presentation, dealing with mechanically applied Swage Marine Fittings, lends itself very well to the theme of the 1985 NSRP Symposium. .."Moving Ahead With The Implementation Of Advanced Technology."

Mechanically applied pipe connections represent a new generation pipe joining technique that was developed to reduce the ever-increasing costs associated with marine piping fabrication and repair.

When utilizing conventional weld and sil-braze installation methods, the installation requirements are often costly and time consuming. There is a high skill level required for welders installing high pressure piping systems. The maintenance of this skill is accomplished through systematic training, qualification and certification. The quality and integrity of conventionally installed piping systems are mostly dependent on the skill level of the installer.

Conventional Piping Installations

The means of attaching sections of piping and the installation of components within a piping system will vary with systems, media, pressure, temperature and pipe material.

The primary pipe joining methods commonplace in the marine industry are welding, silver brazing and threading.

Welding

Welding is the most common means of interconnecting ferrous piping. Arc welding has historically been a major problem area in marine pipe production. There are a number of variables that must be closely controlled to guarantee joint efficiency.

Pipe welding can become a very uncomfortable process in many shipboard environments which in turn>effects overall productivity.

The fact that the welding process elevates the immediate weld zone to liquid temperatures causes additional problems.

The metallurgical properties of the piping and fitting material are disturbed during the installation. In addition to the chemical and physical changes that occur, a heat affected zone is established, wherein, depending on material, metallurgical and physical properties such as localized annealing are highly probable. Other factors such as potential weld inclusions and porosity must be considered.

After the welded installation is completed there is always a probability of joint rework. The percentage of rejected pipe welds will vary with each shipyard, but weld reject rates are always a consideration with some yards documenting an unbelievable amount.

Of course the installed system is then subjected to non-destructive testing, hydrostatic testing and flushing. Welded installations typically involve high labor costs and comparatively low material costs.

Brazing

Commonly used to attach cuprous piping and components is also a labor intensive technique that generally requires highly skilled technicians.

There are several factors that must be considered beyond the actual mechanics of the sil-braze installation. When silver brazing “in-place” on-board ships, special precautions must be taken to protect the surrounding area. Ventillation ducting, wire-ways, non-structual bulkheads, lighting and equipment interferences must be protected from the open flame of the brazing torch. Avoiding heat-related damage to adjacent components is an additional responsibility of the pipe fabrication crew.

The post-installation cleanliness and flushing requirements for silver brazed piping are also very time consuming and expensive. Hot flushing to eliminate contaminants and flux residue is a major cost factor in cuprous piping installations.

Again the skill level of the installer is a major influence on the quality and integrity of the completed system.

Threaded Systems

Threaded systems are not as commonplace nor as labor intensive as the two methods previously discussed. They are, though, very troublesome due to the significant number of potential leak paths created through the threading process.

This potential for systems leakage and the requirements for subsequent corrective action make the threaded piping system potentially labor intensive.

These three conventional pipe connecting methods have been recognized for years as industry standards.

Reliable cost saving alternatives have been virtually nonexistent -- "until recently."

Swage Marine Fittings

There are now several recognized alternatives to the more conventional pipe joining techniques:

- The Swage Marine Fitting, the generic reference used by Naval Sea Systems Command for PYPLOC® fittings manufactured by Deutsch Metal Components of Los Angeles, California, and

-- The Heat Recoverable Coupling, the NAVSEA reference for Cryofit fittings manufactured by Raychem Corporation of Menlo Park, California.

Both technologies have been topics of technical papers presented at either ASNE or SNAME symposiums.

The most recent presentation on PYPLOK® Swage Marine Fittings was given by Commander Dennis Mahoney at the ASNE Shipbuilding and Repair Symposium in September of 1981.

The information presented in CDR Mahoney's paper was based on PYPLOK® Swage Marine Fitting prototype development and potential cost savings. At that time there were no maritime approvals for the use of Swage Marine Fittings nor were there any studies available of actual PYPLOK® installations.

This paper will discuss actual case histories and Method Improvement Studies compiled by various U. S. Naval activities demonstrating a tremendous cost savings per each installed joint.

Background of SMF (Swage Marine Fitting)

About (15) fifteen years ago the Deutsch Company developed a technology that came to be known as the "Radial Swage Concept." Whereby the outside diameter of a specially designed fitting is mechanically reduced, brought into contact with the pipe or tube, creating a pre-determined deformation in that pipe or tube thereby providing an intimate mechanical seal.

This technology was first introduced to the aerospace industry-in the form of an aircraft tube connector trade named Permaswage®.

McDonnell Douglas was the first to use the Radial Swage Aircraft Fitting in 1970.

Since then, Permaswage® Radial Swage Fittings have been designed into virtually every aircraft manufactured in the free world; including the B-1 bomber, the Cruise Missle and the Space Shuttle.

Permaswage® fittings are standard repair items on all military aircraft with state-of-the-art radial swage tooling covered by a Mil-Spec (Mil-K-87957).

In March of 1978, Deutsch Metal Components contacted Naval Sea Systems Command with a development proposal for a marine version of the Permaswage® aircraft tube connector.

NAVSEA was very receptive to the possibility of marine applications of this very successful Radial Swaged Aircraft Fitting. After extensive review of the Deutsch proposal, NAVSEA decided to proceed with the PYPLOK® project.

In conjunction with David Taylor Naval Research and Development Center (DTNSRDC Annapolis, MD), NAVSEA developed an extremely demanding test schedule for PYPLOK® Swage Marine Fittings that included the following tests:

Hydraulic System Qualification (3,000 psig)

Impulse test - 1,000,000 cycles at 70 CPM, 3750 psig peak pressure.

- Flexure test - 80,000 cycles at 3750 psig static pressure and a 60 KSI bending stress for CRES fittings, 44 KSI for CNA fittings at a rate of between 7 and 35 CPM.

- MIL-S-167 vibration test - while pressurized at 3.,000 psig, at frequencies between 4 and 50 Hz, with a 2-hour period at either resonant frequency or 50 Hz if no resonance was found.

- MIL-S-901C shock test (at 3,000 psig).

- High temperature aging test 275° ±5°F (132 -137°C) for 1 week.

  Burst test (five times pressure rating of pipe minimum).

- Compatibility testing - on thin wall CRES (.065 wall, Sch. 5) and 90/10 CNA (.072 wall, CL 200).

- Tensile pull-out - tensile strength of fitting sample must meet or exceed the minimum yield strength of the pipe material.

Pneumatic System Qualifications (6,000 psig)

Combined impulse/flexure - 80,000 cycles, pressures from O to 5,625 psig, bending stresses from O to 60 KS I for CRES, and O to 44 KS I for CNA. The rate of cycling was six to eight per minute. At the completion of this test, a proof test at 9,000 psig was performed for 5 minutes. At intervals of approximately 10,000 cycles the procedure was interrupted, and with the peak pressure, and bending stress still applied the samples were subjected to a cold soak at -100°F (-73°C) for 1 hour using solid CO_2. The test medium was MIL-H-5606 hydraulic oil.

- Vibration test - similar to that indicated in (a) above, sample pressurized to 6,000 psig.

  MIL-S-901C shock test (at 6,000 psig).

High temperature aging test 450°F ±5°F (232°C) for 1 week.

- Burst testing (24,000 psig, minimum).

- Compatibility testing of the high pressure rated fitting on thin-wall pipe/tubing.

These tests were conducted on the following pipe materials:

- CRES (Corrosion Resistant Steel)
- Carbon Steel
- 70/30 CNA
- 90/10 CNA
- Copper

All pipe wall thickness were tested in ferrous piping to Schedule 160 and in cuprous pipe to Class 6000.

This exhaustive testing was conducted over a (4) four year period and independently funded by Deutsch Metal Components.

The satisfactory completion of all required testing and the positive results of numerous trial applications were acknowledged by Naval Sea Systems Command in a blanket approval letter issued in January 1985 approving the Navy-wide use of PYPLOK® Swage Marine Fittings.

This NAVSEA approval letter states that PYPLOK® Swage Marine Fittings are approved for use on systems with an operating temperature of -60°F to + 400°F. Fittings manufactured from 316L CRES are approved for use Up to 1-1/2″ NPS (1.900″) on piping materials of carbon steel and stainless steel in all wall thicknesses up to Schedule 160.

Fittings manufactured from 70/30 Copper Nickel (MIL-C-15726) are approved for use on piping materials of 70/30 CUNI, 90/10 CUNI and copper in wall thicknesses up to Class 6000.

As of this writing, PYPLOK® Swage Marine Fittings are not approved by NAVSEA 08 for use on ships or submarines under the cognizance of the U. S. Navy Nuclear Power Directorate.

Case Histories

PYPLOK® fittings are, however, approved for use in systems onboard non-nuclear surface ships.

Several Method Improvement Studies conducted by the U. S. Navy have demonstrated that through the use of Swage Marine Fittings, shipyards can realize cost savings upwards of 70% on P-1 and P-2 ferrous piping systems and upward of 50% on P-3A and P-3B cuprous piping systems.

A study conducted by production Engineering, Code 383, at Puget Sound Naval Shipyard (PSNS) of a fitting installation on the USS Constellation reflected a cost savings of $64K on 314 installed fittings of various configurations. This breaks down to a very impressive savings of $203.00 per installed fitting. This study did not include any savings in systems flushing.

A similar study was conducted by production Engineering Code 383 at Charleston Naval Shipyard (CNSY) .

Shop 56 installed (130) PYPLOK® Swage Marine Fittings on the CO_2 activation side of the Halon 130-1 System onboard the USS Mahan (DDG-42) thereby eliminating (312) P-1 weld joints. The total documented savings was $32,879.32 or a savings of $252.00 per installed fitting.

These figures we compiled by using both standard Navy stabilized material and labor rates.

One other Method Improvement Study was documented by the Shore Intermediate Maintenance Activity, Norfolk, Virginia. This was a cost savings evaluation by SIMA, Norfolk of a repair to the ASROC loader hydraulics system (JSN WS01-0487) onboard the USS Harry E. Yarnell.

A small quantity of PYPLOK® Swage Marine Fittings were used to effect the repair and the cost savings was documented to be $403.00 per installed fitting.

Benefits of Swage Marine Fittings

How is it possible to demonstrate such a dramatic cost savings through the use of PYPLOK® Swage Marine Fittings?

The theory behind the development of PYPLOK® was to controllably increase the material cost of the fittings required for an installation and dramatically reduce the associated man-hour requirements. The more labor intensive the piping project, the greater the reduction in direct and indirect labor cost.

If Swage Marine Fittings are given the proper considerations during various stages of assembly and fabrication, the piping can all be pre-cleaned and pre-pickeled. Post installation flushing requirements can be minimized or excluded; non-destructive testing is completely eliminated.

Due to the absence of any hot-work during the PYPLOK® installation, there is no need for a fire watch or any gas freeing.

Fittings can be installed in repair applications without systems drainage or precautionary flushing. Fittings can even be installed in various explosive atmospheres.

The PYPLOK® system is a deliberate system, wherein the installer can piece a system together and verify dimensions and alignment prior to swaging. The installed fittings are one piece, permanent and tamper-proof after installation.

PYPLOK® fittings are manufactured in NPS, OD and metric sizes up to 2" NPS. They are available in materials of 70/30 CUNI, 316L CRES and Carbon Steel. Although the U. S. Navy has only approved the use of standard configurations, they are commercially available in various pressure rated flanges, reducers and adapters.

This technology lends itself to the development of a never ending variety of configurations designed to satisfy the needs of the marine piping industry.

The international market place has been most receptive to this technology. PYPLOK® Swage Marine Fittings are presently being used by the French Navy for the repair of non-nuclear systems on nuclear submarines.

The British are using PYPLOK® fittings for both repair and new construction in marine and industrial projects.

In Japan, IHI has developed a design specification for PYPLOK® applications on numerous marine projects.

The implementation of this technology is a worldwide interest that affects marine and industrial projects on an international scale.

Specifications and Approvals

In addition to the NAVSEA approval discussed earlier, PYPLOK® fittings have been approved by virtually every maritime approval agency in the world including Lloyd's, NKK? DNV and the U. S. Coast Guard. American Bureau of Shipping has included PYPLOK® Swage Marine Fittings under their Equipment Type Approval Program..

A Military Performance Specification on Swage Marine Fittings (SMF) has recently been submitted to Naval Sea Systems Command for review.

The ASTM F-25 Committee has a task group F-25.09.13 responsible for developing a performance specification on PYPLOK® (referenced as "Mechanically Applied Fittings") . This document is presently out on preliminary ballot to the ASTM piping subcommittee.

PYPLOK® fittings have been specifically called out as an option in Section 505 of the Arleigh Burke DDG-51 piping specifications.

In the petro-chemical industry, PYPLOK® technology has been the subject of industry specifications developed by Exxon International, Dow Chemical, Dupont and others.

The Future

The future of this technology is unlimited. With an approved MIL-SPEC and ASTM-SPEC, PYPLOK® type fittings will be included in both MIL-STD-438 and MIL-STD-777. This development will provide marine design engineers with the flexibility to specify PYPLOK® Swage Marine Fittings on design drawings if the applications are considered to be cost effective.

Given the amazing reliability of installed PYPLOK® fittings and the proven cost effectiveness in service, these Swage Marine Fittings are destined to revolutionize the pipe connecting industry.

A shipyard is truly “moving ahead” through implementation of this advanced technology.

REFERENCES

1. "Marine Applications of Externally Swaged Pipe Fittings" by CDR Dennis Mahoney presented to the ASNE Shipbuilding and Repair Symposium September 18, 1981.

2. Method Improvement Study by Puget Sound Naval Shipyard Code 383 entitled "Comparison of 3000 PSI CRES Swage Marine Fittings (SMF) and Conventional Weld Fittings" FSR: 0383-8091 dated December 2, 1983.

3. Method Improvement Study by Charleston Naval Shipyard Code 383 entitled "Swage Marine Fittings (PYPLOK®)" SER: 380-1432 dated June 5, 1984.

4. Cost Savings Analysis by Shore Intermediate Maintenance Activity Norfolk Naval Station entitled "PYPLOK® System on USS Yarnell" dated May 9, 1985.

MARINE INDUSTRY STANDARDS OF THE U.S. AND THE WORLD

Presented at

The National Shipbuilding Research Program

Annual Technical Symposium

By

Robert B. Toth

R.B. Toth Associates

ABSTRACT

This paper provides an overview of standards developed or invoked by national and international organizations for the marine industry. Data on standards promulgated by U.S. voluntary and government organizations are presented and compared with those standards available to shipbuilders in other nations. The sources of international and national mandatory standards are reviewed and the U.S. standards system is compared with other nations. A critical deficiency in the U.S. is the relatively small number of fully definitive voluntary standards that can be used for competitive procurement. Recommended action by the marine industry and the standardization community is presented, focusing on the need to effectively apply the limited resources that are available.

MARINE INDUSTRY STANDARDS OF THE U.S. AND THE WORLD

INTRODUCTION

This paper was developed at the invitation of the SNAME SP-6 Secretary to assist the Panel in its long-range planning. The aim is to provide benchmarks from which U.S. marine standards can be developed and some definition of the scope of the task. Data has been developed from a number of sources and related projects including

- preparation of the National Bureau of Standards Directory of Standards Activities of Organizations in the United States, SP 681;

  a comprehensive assessment of the Department of Defense Specifications and Standards Program;

  consultation sponsored by the United Nations Industrial Development Organization at the Rio de Janeiro shipyard of EMAQ-Engenhario E Maquinas S.A.;

  research for tune chairman of the National Science Board's Committee on Maritime Standardization;

  nine years service on the mechanical systems and electrical systems committees of the American Boat and yacht Council; and

  the online database of standards and specifications, TechData developed and maintained by Information Handling Services, Inc.

More than fifty years ago, in 1933, the U.S. had about 5000 standards in use nationally. About half of these were Government documents. In the Commerce Department's Standards Yearbook of 1933 four of the 350 standards developing organizations are identified as "...making standardization the major feature of their activities:

American Standards Association
American Society for Testing Materials
Central Committe on Lumber Standards
American Marine Standards Committee"

The American Standards Association (ASA) was one of the earlier names of the American National Standards Institute (ANSI). ASTM designates itself today as the American Society for Testing and Materials. The other two organizations became defunct as the Depression took its toll of American industry and commerce.

In 1933 these four organizations published nearly half of this country's private sector standards. As shown in Table 1 there were 256 standards specifically prepared for maritime applications.

Table l-Quantity of Standards Available in 1933 from Major Standards Developers

ASA	211	
ASTM	441	released
	224	tentative
CCLS	23	
American Marine Standards		
	96	hull
	36	machinery
	27	ship operations
	7	port facilities
	1	special
Total	256	

SOME BASIC DATA

Today, the U.S. has more than 81,000 standards (See Table 2). Compare this to 20 years ago when there were 39,500 government standards and less than 14,000 private sector standards (See Figure 1). Growth has been primarily in the private sector, and is increasing at an average rate of 3.5 percent per year. In other developed countries the growth rate is approximately five percent per year. The number of International Organization for Standardization (ISO) standards has increased in the last ten years at a rate of nearly 12 percent per year. As shown in Table 3 the U.S. has one of the largest standardization resources in the world.

Forty percent of U.S. standards have been developed within the private sector by about 400 organizations. About 270 of these have ongoing standards development programs, the remainder have one or two standards but are not in the mainstream of U.S. standardization activities. Figure 2 is a breakdown of the standards developing organizations. Twenty of them are responsible for nearly 80 percent of the standards. Fourteen of these develop standards for industry and these are listed in Table 4. Note that ground and air transportation are major developers of standards for their own use.

TABLE 2-Current U.S. Standards

Government	
Defense	38,000
Federal	6,000
Other	5,000
(60%)	49,000
Private Sector	
Scientific & Professional	12,600
Trade Association	11,200
Standards Writing	8,700
(40%)	32,500
Total	81,500

TABLE 3—World Standards Development

USSR	83,000
USA	81,500
F. R. Germany	24,000
P. R. China	14,000
India	12,000
France	11,000
U.K.	9,600
Japan	8,300
Italy	8,000
Sweden	6,000
Canada	5,500
Spain	5,500

TABLE 4—Developers of Industrial Standards

	No. of Standards
ASTM	7,500
Society of Automotive Engineers	4,200
Aerospace Industries Assn.	2,800
Association of American Railways	1,350
American National Standards Institute	1,200*
Factory Mutual	600
American Society of Mechanical Engineers	550
Electronic Industries Assn.	480
Institute of Electrical & Electronics Engineers	500
Underwriters Labs.	465
American Railway Engineers Assn.	400
American Petroleum Institute	350
Technical Association of the Pulp & Paper Industry	270
National Fire Protection Assn.	260

*Copyright assigned to the American National Standards Institute.

TABLE 5 -Categories of Military Specifications and Standards

Military Products & Equipment	9,000	25%
General Engineering	1,300	3%
Materials	4,700	12%
Parts	11,500	30%
Industrial Equipment	9,000	24%
Consumables	2,500	6%
Total	38,000	

FIGURE 1 U.S. STANDARDS GROWTH 1964 - 1984

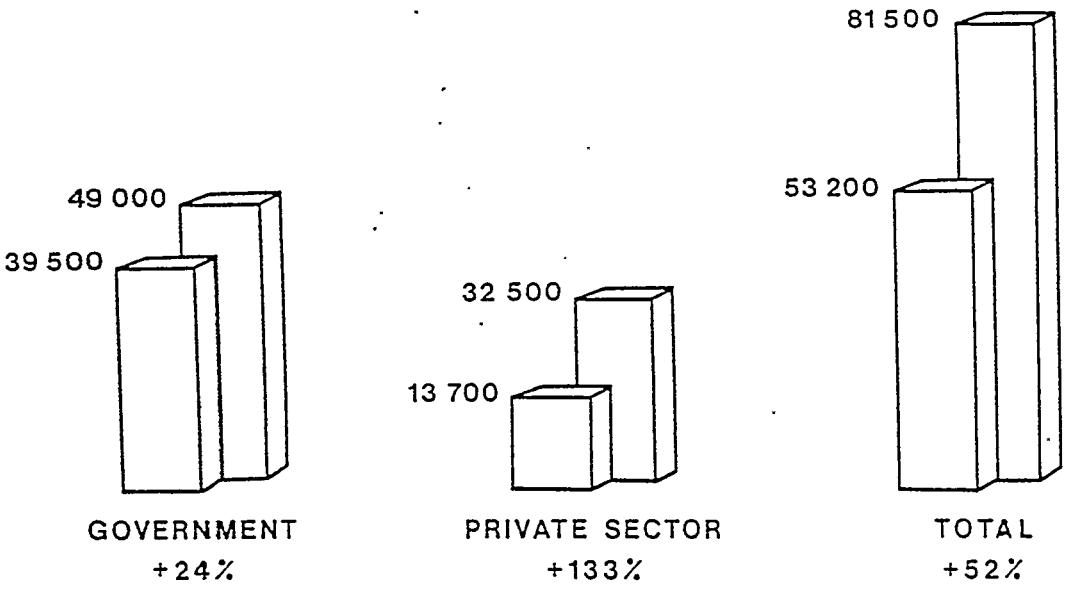
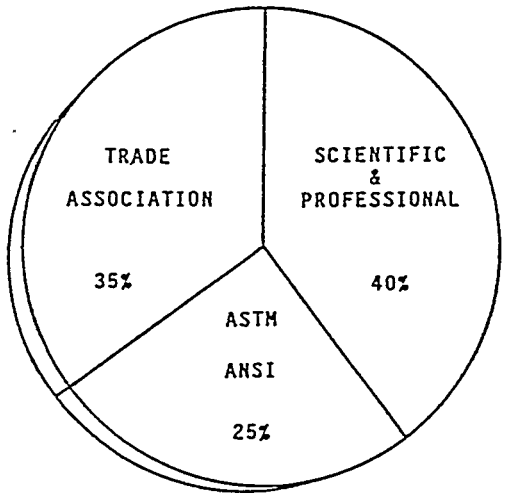


FIGURE 2

CLASSIFICATION OF STANDARDS DEVELOPERS



These private sector standards are widely used by government agencies. DoD has formally adopted more than 3,600 industry standards and references thousands more in its own standards.

The largest body of standards in the free world have been developed by the Department of Defense. As shown in Table 5 only about one quarter of the 38,000 active standards are for munitions and war materiel. The remainder provide very complete documentation for everything from microelectronics to bulldozers. Many industries make extensive use of military specifications and standards in their commercial products.

The rate of standards development by DoD has slowed to the point where as many standards are being canceled as are created. In the past four years, DoD canceled 3,630 of its specifications and standards, created 2,962 new ones, and adopted 1,182 standards industry standards.

STANDARDS FOR THE MARINE INDUSTRY

Table 6 lists the quantities of military specifications and standards for the Federal Supply Classes (FSC's) of special interest to the marine industry.

Table 6-Marine Related Military Specifications and Standards

FSC	CLASS	QUANTITY
19--	Ships, small craft; docks	75
2010	Propulsion components	5
2020	Rigging	2
2030	Deck machinery	12
2040	Marine hardware & hull items	67
2090	Miscellaneous equipment	26
2825	Steam turbines	5
4220	Marine lifesaving & diving	107
4410	Boilers	18
4420	Heat exchangers & condensers	15
4620	Water distillation	9
4810	Powered valves	10
5830	Intercoms & pa systems	45
6320	Shipboard alarms & signals	11
		407

Ships, of course, make use of a wide variety of components and equipment that are not exclusive to the marine industry. Table 7 summarizes the standards that constitute the database of government and industry standards that are pertinent to the marine-industry.

Table 7-U.S. Database of Marine Industry Standards

Government		Industry	
Mil (Navy)	400	Marine	100
Mil (Other)	2500 est.	Other	2500 est.
Federal	700 est.		
Navy Dwgs	3500		
	7100		2600

The 3,500 Navy standard drawings may be considered by some to be too specialized for general application but a careful review will indicate that the majority cover equipment and installations that are applicable to non-combatants. The majority of the marine standards developed by industry have been prepared by the American Boat and Yacht Council and while most are not applicable to ships, they are excellent documents for captain’s gigs and similar auxiliaries.

Table 8 demonstrates that the body of marine standards developed by other nations is relatively modest. Many less developed nations make extensive use of the standards of other countries.

Table 8-Marine Industry Standards of Some Other Nations

Japan	860
Germany	450
France	280
P R China	140
United Kingdom	130

PRODUCT STANDARDS FOR PROCUREMENT

A widely held belief is that all government standards are excessively restrictive or "gold-plated" resulting in the purchase of products that are not cost-effective. While there are certainly examples where this is the case, the majority of Federal and Military Specifications are well developed documents that enable materials and components to be purchased competitively from the lowest bidder; assess the quality of the product and, if warranted, reject it. State purchasing agencies make extensive use of government specifications and standards. Many industries use government specification in their commercial products. In such areas as semiconductors and integrated circuits, wire and electrical connectors; lubricants and finishes, many manufacturers of commercial products rely on government documents. They would not do so if they were not cost effective.

A major deficiency of our inventory of private sector standards is the small number that define a product with sufficient specificity to enable competitive procurement. While about 25,000 government standards fully define product requirements, only six to eight thousand from the private sector are product standards. Most of these are for fasteners and materials primarily for application in aircraft and railways. Private sector standards are most commonly used by government and industry as second tier reference documents. These define individual test methods; dimensional tolerances, color codes and similar individual parameters and characteristics which, when selectively applied, together define the end product. For example, there are more than 100 industry standards on the constituents of paints; sampling, analysis and test methods for paints; and recommended practices for preparing surfaces prior to painting, but there are hardly any private sector standards for the various types or grades of paints. As a result, the large retailers, government agencies, ship owners and other major users of paint have prepared their own specifications that define performance requirements or proven formulations.

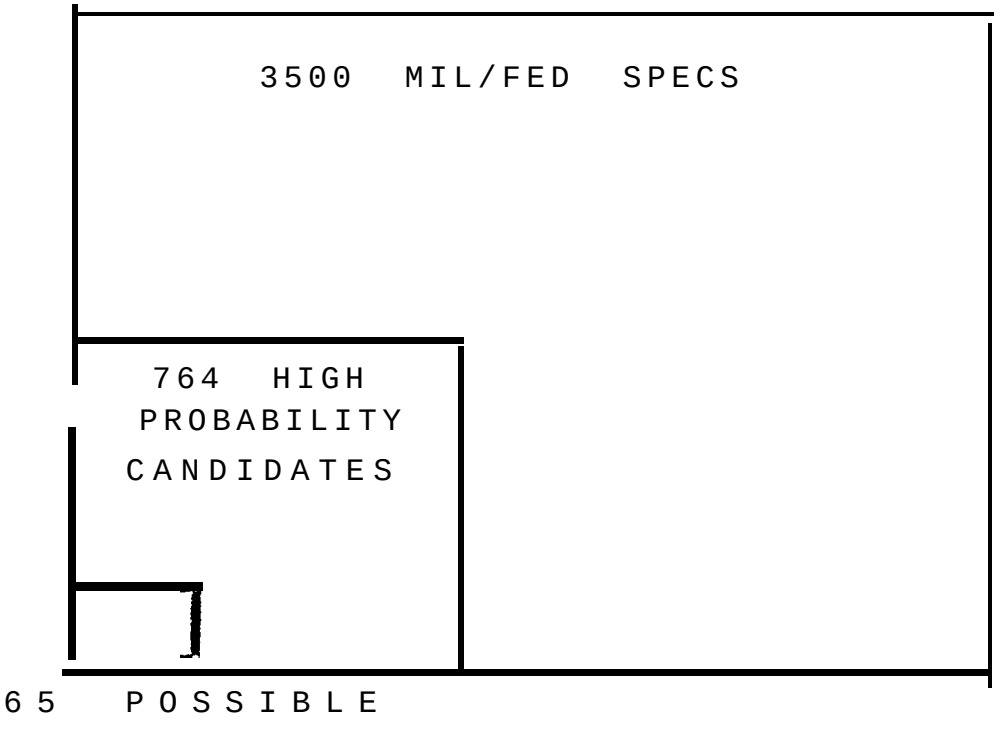
In March 1983 the Maritime Administration, U.S. Department of Transportation, completed a study of 764 military specifications for a wide variety of commodities used on board commercial and navel ships. These were selected from a base of about 3,500 specifications that are applied by the Navy. It was believed that there was good probability that these 764 could be replaced by commercial industry standards with an adequate (not necessarily combat rated) level of commercial performance and quality. The commodities ranged from switches and

valves to bearings and hand tools, padlocks to awnings. The analysis identified only 65 possible substitute industry standards (8.5%). See Figure 3. Even many of these are not product standards that can be used for procurement. While the Underwriters Laboratories standard on locks is useful as a reference document to define pick resistance many other parameters need to be provided including basic dimensions, corrosion resistance, and type of keying before a lock supplier could respond to a purchase order for a UL 437 lock.

FIGURE 3

MARAD STUDY TO IDENTIFY

COMMERCIAL STANDARD SUBSTITUTES



MANDATORY AND VOLUNTARY INTERNATIONAL STANDARDS

In recent years international standards have started to have a significant effect on standards development in the U.S. and have influenced standards development in other countries for a much longer period. Shrinking domestic markets have forced U.S. and foreign suppliers to compete fiercely for third world markets where international standards are preferred. In response to their constituencies most U.S. standards developers are bringing their standards in consonance with international standards. In addition, foreign built or foreign designed equipment has a significant share of the market in many industries and this equipment, more often than not, reflects requirements and ratings set by international standards.

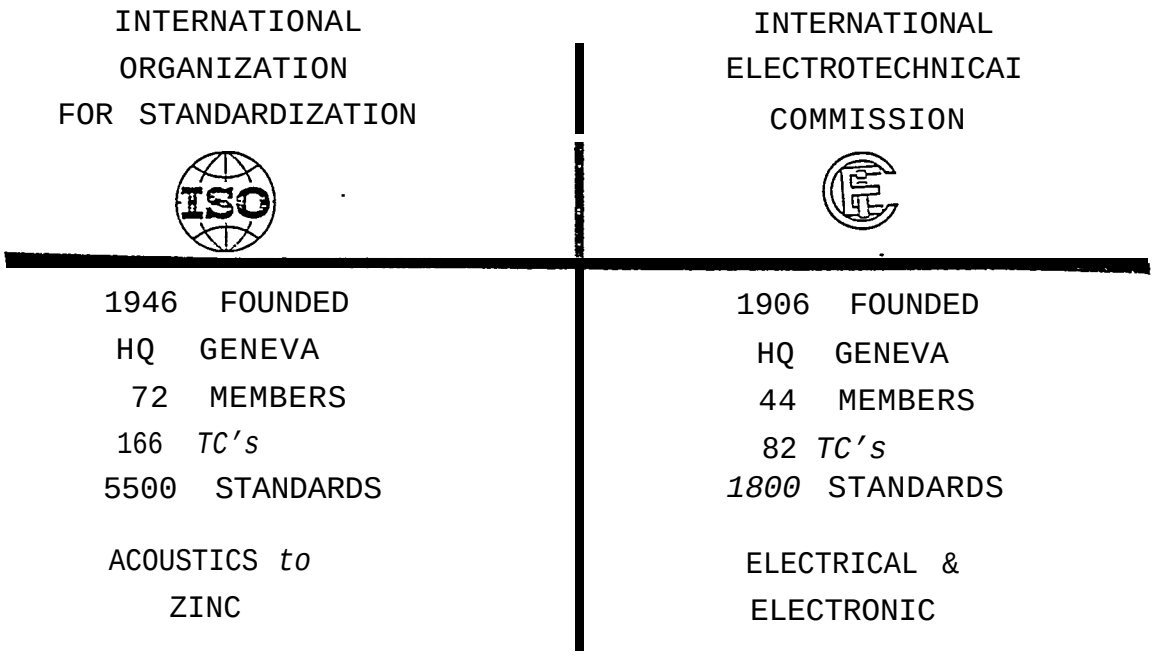
The most influential international standards are those developed by treaty organizations. It is usually mandatory that their standards be adopted by nations which are signators to the treaty. There are about seventy-five treaty organizations that establish standards. Those that most directly affect marine interests are the International Maritime Organization (IMO) and the World Health Organization (WHO). IMO has developed dozens of codes affecting the design and operation of ships ranging from safety of life and pollution prevention to the construction of ships carrying dangerous chemicals and minimum requirements for containers. The WHO Guide to Ship Sanitation is the basis for most national regulations and standards in this field.

Another 125 international organizations develop voluntary standards. As shown in Table 9 the International Organization for Standardization (ISO) and the International Electrotechnical Commission have developed the majority of the world's international standards. Figure 4 summarizes the effort of these two organizations. No more than twenty-five of their standards are true product standards. Technical Committee 8 (TC 8), Shipbuilding, is one of ISO's oldest committee and has prepared more than 120 standards. It is organized around twelve subcommittees ranging from Ships Scuttles and Windows, to Shipborne Barges, and RO/RO Ship to Shore Installations. The U.S. participates - and that to a limited extent - on four of the twelve subcommittees: SC5 Machinery and Piping, SC 10 Deck Machinery, SC 14 Yachts, and SC 15 Computer Applications in Shipbuilding. Yachts may soon be spun-off as a separate Technical Committee.

Most of the IEC work of interest to ship builders centers on Technical Committee 18, Electrical Installations in Ships. A series of standards have been developed that constitute an international shipboard electrical code. These standards include requirements for system design; all types of equipment including generators, motors, and switchgear; batteries; lighting, cooking appliances; and cables and their installation ranging from low voltage to coaxial. IEC Technical Committee 80 was recently organized to develop standards for Advanced Electronic Navigational Instruments.

TABLE 9—INTERNATIONAL STANDARDS	
ISO	5500
I EC	1 800
22 OTHERS	1 500
180 MORE	1 500
TOTAL	10 300

FIGURE 4



Outside of the United States, then, there are about 200 international standards directly applicable to the marine industry and more than 5000 national standards.

APPLYING THE WORLD'S STANDARDS

EMAQ, a major Brazilian shipbuilder, makes effective use of standards from throughout the world. Figure 5 presents the results of a study of the application of standards on a 37,800 ton bulk carrier designed and built by EMAQ. More than 46 percent of the materials and products used to build this ship are defined by company or national standards. These standard materials and products constitute nearly 22 percent of the total cost of purchased items for this ship.

EMAQ maintains a computerized database of marine standards from the major shipbuilding countries of the world. An excerpt is presented in Figure 6. (SIS, DIN, JIS, GOST, and AFNOR, are the national standards bodies of Sweden, Germany, Japan, Russia, and France). When creating a new company standard EMAQ's standards specialists review pertinent foreign and international standards and incorporate the best features in their company standard.

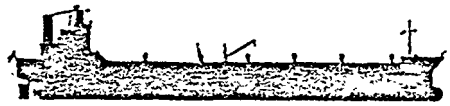
Like many developing countries Brazil needs to conserve its supply of "hard currency". For lack of indigenous suppliers Brazilian shipbuilders had to import many kinds of marine equipment at considerable expense to the builders and the nation. Under the auspices of the Brazilian Society of Naval Architects and Marine Engineers, national standards have been established which define products used by all Brazilian yards. Sufficient market has thus been established to make it worthwhile for suppliers to tool-up. As an example, to encourage Brazilian suppliers to produce portlights and windows, Brazil's counterpart to SNAME SP-6 developed a product standard based on ISO envelope dimensions and materials and hardware from the Marine Series of the British Standards Institution. Consensus was then established through the Brazilian standardization institute, ABNT. Not only did this expedite preparation of a Brazilian standard but it assured acceptance by the classification societies.

FIGURE 5

EMAQ - ENGENHARIA E MAQUINAS S.A.

Hull No. 340

Bulk Carrier



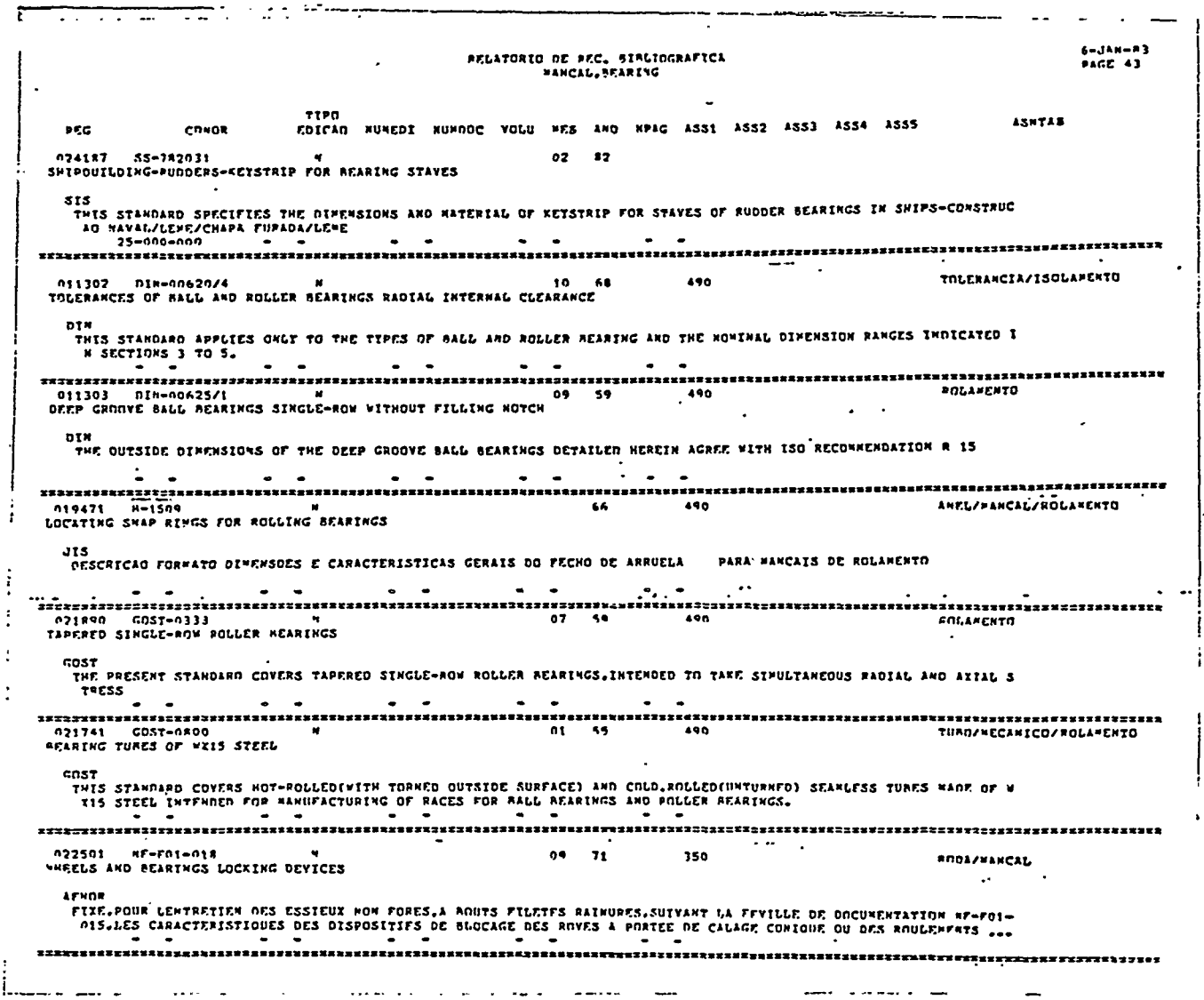
MATERIAL GROUPS	NO. OF STD. ITEMS	% (*)	COST OF STD. ITEMS	% (**)
Welding		0.6	$215,906	3.87
Non-Ferrous	24	0.7	2,183	0.03
Others	29	0.8	3,647	0.06
Ropes and Accessories	34	1.0	1,615	0.02
Packing Material	36	1.1	1,591	0.02
Steel Profiles	36	1.1	131,741	2.35
Other SteeI Materials	50	1.5	12,449	0.22
Hull Fittings	52		63,426	1.15
8uilding Material	80	2.5	7,724	0.13
Steel Plates			507,629	9.05
Electricity	134	4.2	61,103	1.08
Fasteners	360	11.1	16,354	0.29
Piping and Accessories	554	17.1	198,142	3.52
Total	1,501	46.2	$1,223,510	21.73

(*) Related to the total number of items used on hull 340 (3,249 items)

(**) Related to the total cost of materials of hull 340 ($5,615,000)

February 1983

FIGURE 6



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                                                                                                                    6-JAN-83
                                    RELATORIO DE REC. BIBLIOGRAFICA                                                 PAGE 43
                                          MANCAL,BEARING

                          TIPO
   REG          CONOR     EDICAO  NUMEDI  NUMDOC  VOLU  MES  ANO  NPAG  ASS1  ASS2  ASS3  ASS4  ASS5          ASNTAB
 024187   SS-782031          W                          02   82
SHIPBUILDING-RUDDERS-KEYSTRIP FOR BEARING STAVES

  SIS
   THIS STANDARD SPECIFIES THE DIMENSIONS AND MATERIAL OF KEYSTRIP FOR STAVES OF RUDDER BEARINGS IN SHIPS-CONSTRUC
    AO NAVAL/LEME/CHAPA FURADA/LEME
       25-000-000
================================================================================================================
 011302   DIN-00620/4        W                          10   68        490                          TOLERANCIA/ISOLAMENTO
TOLERANCES OF BALL AND ROLLER BEARINGS RADIAL INTERNAL CLEARANCE

  DIN
   THIS STANDARD APPLIES ONLY TO THE TYPES OF BALL AND ROLLER BEARING AND THE NOMINAL DIMENSION RANGES INDICATED I
    N SECTIONS 3 TO 5.
================================================================================================================
 011303   DIN-00625/1        W                          09   59        490                          ROLAMENTO
DEEP GROOVE BALL BEARINGS SINGLE-ROW WITHOUT FILLING NOTCH

  DIN
   THE OUTSIDE DIMENSIONS OF THE DEEP GROOVE BALL BEARINGS DETAILED HEREIN AGREE WITH ISO RECOMMENDATION R 15
================================================================================================================
 019471   M-1509             W                          66        490                          ANEL/MANCAL/ROLAMENTO
LOCATING SNAP RINGS FOR ROLLING BEARINGS

  JIS
   DESCRICAO FORMATO DIMENSOES E CARACTERISTICAS GERAIS DO FECHO DE ARRUELA    PARA MANCAIS DE ROLAMENTO
================================================================================================================
 021890   GOST-0333          W                          07   58        490                          ROLAMENTO
TAPERED SINGLE-ROW ROLLER BEARINGS

  GOST
   THE PRESENT STANDARD COVERS TAPERED SINGLE-ROW ROLLER BEARINGS,INTENDED TO TAKE SIMULTANEOUS RADIAL AND AXIAL S
    TRESS
================================================================================================================
 021741   GOST-0800          W                          01   55        490                          TUBO/MECANICO/ROLAMENTO
BEARING TUBES OF MXIS STEEL

  GOST
   THIS STANDARD COVERS HOT-ROLLED(WITH TORNED OUTSIDE SURFACE) AND COLD,ROLLED(UNTURNED) SEAMLESS TUBES MADE OF M
    X15 STEEL INTENDED FOR MANUFACTURING OF RACES FOR BALL BEARINGS AND ROLLER BEARINGS.
================================================================================================================
 022501   NF-F01-018         W                          09   71        350                          RODA/MANCAL
WHEELS AND BEARINGS LOCKING DEVICES

  AFNOR
   FIXE,POUR LENTRETIEN DES ESSIEUX NON FORES,A ROUTS FILETES RAINURES,SUIVANT LA FEVILLE DE DOCUMENTATION NF-F01-
    015,LES CARACTERISTIQUES DES DISPOSITIFS DE BLOCAGE DES ROUES A PORTEE DE CALAGE CONIQUE OU DES ROULEMENTS ...
================================================================================================================
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Typical citations for bearings selected at random from EMAQ standards database

RESPONDING TO U.S. NEEDS FOR MARINE INDUSTRY STANDARDS

There has been considerable discussion within the U.S. marine industry and standards circles on the need for a comprehensive set of up-to-date industry standards. The limited resources available for this effort must be used judiciously so that not only are basic standards prepared but important standards for new technology are developed. Timely standardization action is often the catalyst for introduction of cost-effective new technology. We could very well emulate the approach of some of the developing nations and adapt or adopt up-to-date existing standards. National standards for basic products could then be prepared with considerably less effort than "starting from scratch" or trying to update an obsolete standard. Manpower thus saved could be applied to newer technology.

A few years ago, some Japanese national standards for deck fittings were reviewed with this objective in mind. For various reasons these standards were not considered appropriate for American manufacturing practices and usage. While these Japanese standards may have been inappropriate, those prepared by other countries may be exactly what we need. SNAME SP-6 should consider <u>adapting</u> U.S. Navy, foreign and international standards by

- cutting and pasting into U.S. format, and/or
- copying tine standards with U.S. conventions for measurement and language and applicable second tier reference documents.

Where appropriate, <u>adopt</u> existing standards:

- Use a cover sheet indicating that; through the consensus process, a particular standard is adopted by the marine industry. If necessary, exceptions or substitutions can be noted on tine cover sheet. This is the process by which more than 3;600 industry standards have been adopted by the Department of Defense.
- Similarly, ISO and IEC standards can be adopted as national standards. American National Standards Institute procedures, based on ISO/IEC Guide 3; provide for designation of adoption by applying the ANSI prefix, e.g. AINSI/ISO 334-1979. While this practice is just taking hold in the U.S. it is widely used by the rest of the world. In Germany more than 5,000 ISO and IEC standards are designated DIN ISO ---- and DIN IEC ----- Sixteen percent of Britain's standards and 43 percent of Denmark's are adopted ISO and IEC standards. .

- Prepare lists of standards preferred by the marine industry. By doing so SNAME SP-6 would:

    (1) define the universe and focus on those areas that urgently need new or updated standards;

    (2) provide a useful tool to yards and design agencies, most of which do not have standardization activities to perform this basic task; and

    (3) assist suppliers and distributors to identify those types of products that should be in inventory.

The techniques outlined are widely used and proven and make effective use of available standardization resources. All are compatible with the consensus process of standards development. The circulation of Lists of Preferred Standards is particularly effective in demonstrating to management that standards impact all areas of the design, production; and operation cycle.

A necessary tool for this effort is a bibliographic database of those standards that could be of use to the marine industry. Such a database can be quickly and economically prepared using existing data sources and readily available inexpensive software. If sufficient use can be demonstrated, such a database could be made accessible to every yard and design agency having a simple, PC type, computer terminal. Additional opportunities and applications would be identified as the database is used. The potential for improving the application of standards in U.S. yards and the opportunity to expedite the development of new standard's through these proposals warrants serious consideration by SNAME and SP-6.

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